AGRUPAMENTO DE ESTUDOS DE CARTOGRAFIA ANTIGA

XII

SECÇÃO DE COIMBRA

HUGO HELT AND THE ROJAS ASTROLABE PROJECTION

BY

FRANCIS MADDISON

JUNTA DE INVESTIGAÇÕES DO ULTRAMAR

COIMBRA ✦ 1966

Separata da
REVISTA DA FACULDADE DE CIÊNCIAS
Vol. XXXIX

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by

FRANCIS MADDISON

Fellow of Linacre College, Oxford
Curator, Museum of the History of Science, Oxford University

> «Je me suis permis d'attirer l'attention sur ces détails parce que la question de la science au XVI[e] siècle se réduit en fin de compte, à mon avis, à la question de ce qu'étaient les savants du XVI[e] siècle. Il faut donc étudier de plus près les hommes de ce siècle...».
>
> V. P. ZOUBOV [1]

Introduction

This paper has been written in the hope that some scholars, with easier access than the present writer to libraries and archives in Spain, the Netherlands, and Belgium, may be led to investigate the life and work of a scarcely known sixteenth century scientific writer and translator, Hugo Helt. The distinguished scholar, Luciano Pereira da Silva, to whose memory this issue of the *Revista*

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[1] Vassili Pavlovitch Zoubov, 'Vitruve et ses commentateurs du XVI[e] siècle', *La Science au seizième siècle. Colloque international de Royaumont 1-4 juillet 1957* (Histoire de la Pensée II), Paris, 1960, p. 70.

is dedicated, was the first to call attention (2) to the possible rôle of Hugo Helt in the development of an important universal astrolabe projection, which is usually attributed to Juan de Rojas Sarmiento. Of the life and career of Juan de Rojas much remains to be learnt; even the dates of his birth and death are unknown. He is remembered by historians of science only as the author of a single book, and the eponym of a type of astrolabe. The opportunity has also been taken here to bring together some scattered information concerning the Rojas projection in the further hope of encouraging a revival of interest in the history of projections as applied to scientific instruments. Many early writers on the astrolabe and on gnomonics were well aware of the historical development of the mathematical basis of their work; modern historians of scientific instruments have tended to leave to historians of geography the study of the history of projections. A detailed history of all projections used in the construction of scientific instruments and in terrestrial and celestial cartography, and of the relationship between them is urgently needed (3). In particular, the knowledge and use of projections in both East and West before the Renaissance requires careful study.

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(2) Luciano Pereira da Silva, 'O Astrolábio universal da Sociedade de Geografia de Lisboa', *Jornal de sciências matemáticas, físicas e naturais*, 3ª série, vol. v (1926), no. 20 (no. 96); reprinted in *Obras completas de Luciano Pereira da Silva*, 3 vols., Lisbon, 1943-6, vol. III, pp. 331-352. The discussion of Helt and the Rojas projection occurs on pp. 337-339, 349.

(3) The classic history of geographical map projections is D'Avezac, 'Coup d'œil historique sur la propection des cartes de géographie', *Bulletin de la Société de Géographie [Paris]*, 5e série, vol. v (avril, mai et juin 1863), pp. 257-361, 438-485; see also Johannes Keuning, 'The History of Geographical Map Projections until 1600', *Imago Mundi*, vol. XII (1955), pp. 1-24, which has a good bibliography; W. G. V. Balchin, 'Map Projections in History', *Impulse* [Mitchell Engineering Ltd., London], no. 2 (September 1957), pp. 9-13.

Astrolabe projections

In this article, we are concerned with a single orthographic (4) projection, which was used on a number of universal astrolabes and sundials (5). The 'ordinary' planispheric astrolabe makes use of a stereographic (6) projection of the celestial sphere from one of the poles on to the plane of the equator (7). It derives from the *Planisphaerium* of Ptolemy of Alexandria (2nd cent. A. D.), though the theory of stereographic projection may be considerably older (8).

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(4) or *orthogonal*. The phrase 'orthographic projection' was introduced by François d'Aiguillon, S. J., in 1613; see Keuning, *op. cit.*, p. 6.

(5) A list, doubtless incomplete, is given the Appendix to this article.

(6) This term also derives from d'Aiguillon; see note 4 above.

(7) All surviving astrolabes of this type known to the author, use a northern projection (*i. e.* from the South pole), but the southern projection is found on certain medieval European public astronomical clocks; see Theodor Wåhlin, *The Mediaeval Astronomical Clock in Lund Cathedral, with a Survey of Some Similar Clocks on the Continent and in England*, Lund, 1930. On the planispheric astrolabe the standard work is Henri Michel, *Traité de l'astrolabe*, Paris, 1947; see also Willy Hartner, 'Asturlâb' *Encyclopaedia of Islam*, new ed., vol. I, fasc. 12, London, 1958, pp. 722-8; Salvador García Franco, *Catálogo crítico de astrolabios existentes en España*, Madrid, 1945; and R. T. Gunther, *The Astrolabes of the World*, 2 vols., Oxford, 1932; other publications are listed by Francis Maddison, 'Early Astronomical and Mathematical Instruments. A Brief Survey of Sources and Modern Studies', *History of Science*, vol. II (1963), pp. 17-50. There are two other main types of astrolabe: the *spherical* astrolabe, which goes back in time at least to Qustâ b. Lûqâ (d. *c.* 922); see Francis Maddison, 'A 15th Century Islamic Spherical Astrolabe', *Physis. Rivista di storia della scienza*, vol. IV (1962), fasc. 2, pp. 101-109; and the *mariner's* astrolabe, invented in the late fifteenth or early sixteenth century for use at sea, see D. W. Waters, 'The Sea — or Mariner's — Astrolabe' in this issue of the *Revista*, pp. 375-406. Neither of these two types of astrolabe involves the use of a projection.

(8) Ptolemy's *Planisphaerium* has been edited by J. L. Heiberg, *Claudii Ptolemaei opera quae exstant omnia*, vol. II, 'Opera astronomica minora' (Bibliotheca scriptorum graecorum et romanorum Teubneriana), Leipzig, 1907, pp. XII-XIV, 225-259. For a discussion

No Hellenistic Greek astrolabes are known to exist; the earliest examples of this type of astrolabe are Islamic and date from the late ninth century (9). In Eastern Islamic lands, in Muslim Spain and other parts of the *maghrib*, and in Christian Europe, the 'ordinary' planispheric astrolabe has a long history, which in Europe lasts until the

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of the problem whether stereographic projection was known to Hipparchus, see D. R. Dicks, *The Geographical Fragments of Hipparchus*, London, 1960, pp. 194-207.

(9) They are: *a)* the astrolabe made by Khafîf, pupil of 'Alî b. ?îsà, in the Museum of the History of Science, Oxford, no. 57-84/155; *b)* an anonymous *rete* from a similar astrolabe, also at Oxford, no. 57-84/156; *c)* an astrolabe by Ahmad b. Khalaf (also a pupil of 'Ali b. 'îsa) in the Bibliothèque nationale, Paris; *d)* the *mater* of an astrolabe made by Hamid b. 'Alî (pupil of one of Khafif's pupils) in 995-6 A. D., in the Museo nazionale, Palermo; *e)* another *mater* by the same maker in the Museum of Islamic Art, Cairo no. 15353; *f)* the so-called 'astrolabe of Pope Sylvester II [Gerbert]' in the Museo di Storia della Scienza, Florence, no. IC 122 [for an explanation of 'IC' astrolabe reference numbers, see Appendix].

The earlier history (*i. e.* between Ptolemy and the manufacture of the instruments listed above) of the applications of stereographic projection cannot be traced in detail; see however, O. Neugebauer, 'The Early History of the Astrolabe', *Isis*, vol. XL (1949), pp. 240-256, and the remarks in the seventh book of the *Kitâb al-fihrist* of Ibn an-Nadîm (10th cent. A. D.), translated by Heinrich Suter, 'Das Mathe- *Zeitschrift für Mathematik und Physik*, 37. Jahrgang, Supplement (Abhandlungen zur Geschichte der Mathematik, Heft VI), pp. 41-42. matiker-Verzeichniss im Fihrist des Ibn Abî Ja'kûb an-Nadîm',

It does not appear to have been pointed out that the distortions in the 'zodiac' of the dome of the Umayyad palace at Qusayr 'Amr, between 711 and 715 A. D. are almost certainly the result of a craftsman copying a stereographic projection of the celestial sphere on to the dome; see K. A. C. Cresswell, *Early Muslim Architecture*, 2 vols., Oxford, 1932-40, vol. I, pp. 289-303. There are also a number of copies of classical manuscripts in which historians of art have detected gross errors in the representation of the heavens. Probably, some of these illustrations are unrecognised attempts, albeit crude, to produce or copy stereographic projections; for examples, see Emmy Wellesz, 'An Early al-Sûfî Manuscript in the Bodleian Library in Oxford. A Study in Islamic Constellation Images', *Ars Orientalis*, vol. III (1959), pp. 6-7; F. N. Estey, 'Charlemagne's Silver Celestial Table', *Speculum*, vol. XVIII, no. 1 (January 1943), pp. 112-117.

end of the seventeenth century, and in Islam until the beginning of the twentieth. Most of the surviving astrolabes are of this type. Its disadvantage is that the projection of the horizon, the circles of altitude (almucantars), and the lines indicating unequal hours engraved on the plate *(tympanum)* under the rotating star-map *(rete)*, must be drawn for the latitude in which it is intended to use the astrolabe. In practice, most astrolabes are provided with a series of plates for use in different latitudes; these plates are placed in the body *(mater)* of the astrolabe, with the appropriate plate uppermost, immediately below the *rete*.

A series of plates was not an entirely satisfactory solution to the problem of using an astrolabe in various latitudes. No such series could cover a comprehensive series of latitudes, without a considerable increase in the weight and bulkiness of the instrument. Moreover, a versatile instrument was complicated to construct well, and therefore expensive. To overcome these inconveniences, there have been designed astrolabes which are universal, that is, usable without substantial change, in any latitude.

The best known, and probably the most common, of planispheric universal astrolabes is the modification by Ibn az-Zarqellu, in Toledo in the eleventh century, of the *lamina universal* of 'Alî b. Khalaf, another astronomer of Toledo in that century. This is the *açafeha* of the *Libros del saber de astronomía* compiled by a group of Jewish and Christian scientists under the patronage of Alfonso X el Sabio, of Castille, about 1276 ([10]). The Zarqellu astro-

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([10]) Manuel Rico y Sinobas (ed.), *Libros del saber de astronomía del rey D. Alfonso X de Castilla*, 4 vols., Madrid, 1863-1866. See also E. S. Procter, 'The Scientific Works of the Court of Alfonso X of Castile: the King and his Collaborators', *The Modern Language Review*, vol. XL, no. 1 (January 1945), pp. 12-29; *idem*, *Alfonso X of Castile, Patron of Literature and Learning*, Oxford, 1951; José A. Sánchez Pérez, *Alfonso X, el sabio*, 2nd ed., repr. Madrid, 1944; and n. 41, below.

Both the *lamina universal* and the *açafeha* (=Arabic *safîha*, 'plate') are described in Rico y Sinobas, *op. cit.*, vol. III, pp. 1-237. See also José M. Millás Vallicrosa, *Estudios sobre Azarquiel*, Madrid-Granada, 1943-1950, *passim*.

labe became generally known in medieval Christian Europe as the *saphaea arzachelis* ([11]), and was revived in the sixteenth century by Gemma Frisius (1508-1555) of the University of Louvain, who called it *astrolabum* [*sic*] *catholicum* ([12]). This type of astrolabe was based on a stereographic projection of the celestial sphere from the vernal point on to the colura of the solstices ([13]). In this projection,

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([11]) Several examples made in Muslim Spain, or in North Africa, have survived. Non-Islamic examples are very rare. An anonymous and composite late gothic astrolabe, *c.* 1350, now in the Museum of the History of Science, Oxford, no. 57-84/175A, includes a *saphaea arzachelis* in the *mater*. The astrolabe made, *c.* 1480, by Hans Dorn of Vienna for Marcin Bylica of Olkusz, an astronomer at the court of Mathias Corvinus of Hungary, includes a *saphaea arzachelis;* it is now preserved in the Collegium Maius of the Muzeum Universytetu Jagiellonskiego, Cracow (see also pp. 5-26 and n. 60, below).

([12]) R. Gemma Frisius, *De astrolabo catholico liber quo latissime patentis instrumenti multiplex vsus explicatur, & quicquid vspiam rerum mathematicarum tradi possit continetur*, Antwerp, 1556. See Michel, *op. cit.*, pp. 18-20, 93-192. On Gemma, see Fernand van Ortroy, *Bio-bibliographie de Gemma Frisius, fondateur de l'école belge de géographie, de son fils Corneille et de ses neveux les Arsenius* (Académie royale de Belgique. Classe des lettres et des sciences morales et politiques. Mémoires, 2e série, vol. XI, fasc. 2), Brussels, 1920.

([13]) The history of this form of stereographic projection before 'Alî b. Khalaf is obscure. Several late fifteenth and early sixteenth century European astronomers made use of the same type of stereographic projection for solving spherical triangles; see J. D. North, 'Werner, Apian and the Meteoroscope', *The British Journal of the History of Science*, vol. III, part I, no. 9 (June 1966), pp. 57-65. Keuning, *op. cit.*, pp. 7-9, gives a general account of the geographical use of all forms of stereographic projection. Stereographic, orthographic, and other projections are used in crystallography for the representation of crystal morphology; for example, a net identical in form to that of the *astrolabum catholicum* of Gemma reappears in 1902 as the 'Wulff net' named after G. V. Wulf (Yu. V. Vulf; 1863-1925) of Moscow, see 'Report on the Ninth Colloquium on the History of Mathematics [Oberwolfach, September 1964]', *The British Journal of the History of Science*, vol. II, part III, no. 6 (December 1964), p. 163. A useful table of crystallographic projections is found in N. F. M. Henry, H. Lipson and W. A. Wooster, *The Interpretation of X-Ray Diffraction Photographs*, London, 1951, p. 24.

the meridians and parallels become arcs of circles, the intervals between them decreasing along both axes towards the centre of the circular boundary of the projection.

Two other universal astrolabe projections were developed. One of these, which was published six years before that of Gemma Frisius, is a main subject of this paper. The other was devised by Philippe de la Hire (1640-1718) in the latter part of the seventeenth century ([14]). It is a projection of the celestial sphere on to the plane of the colura of the solstices from a point between the vernal point and infinity, chosen such that the resulting parallels and meridians, which are arcs of ellipses, are approximately equally spaced ([15]). La Hire thus avoided the inconvenience of the increasing closeness of the parallels and meridians which are found in both the Zarqellu/Gemma projection and the Rojas projection. Though Nicolas Bion, that influencial writer on scientific instruments, highly praised the la Hire projection ([16]), the only examples of its

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([14]) It was described by Nicolas Bion in his *L'Usage des astrolabes, tant vniversels que particuliers...*, Paris, 1702, pp. 21-29, 73-140, presumably from La Hire's 'Leçons du College Royal' (see n. 16 below); see also Michel *op. cit.*, pp. 21, 111-113. A vignette at the top of p. 1 of La Hire's *Sectiones conicæ in novem libros distributa*, Paris, 1685, includes a rather roughly drawn La Hire astrolabe among diagrams of conic sections and a sundial projection. La Hire appears also to have used his projection, this time on the plane of the ecliptic, for 'son Planisphere Celeste que Monsieur Defer a fait graver', Bion, *op. cit.*, p. 22.

([15]) The La Hire projection should not be confused with some of the so-called 'globular' projections; see Keuning, *op. cit.*, pp. 20-21.

([16]) «Monsieur de la Hire donna, il y a quelques années, dans ses Leçons du College Royal une nouvelle construction d'Astrolabe qui a des avantages considerables par dessus celles [*i. e.* of Gemma Frisius and Rojas] dont nous avant parlé cy-devant.

Dans cet Astrolabe les distances des Cercles y sont representées d'une maniere plus conforme au Globe qu'en aucun autre; car ces distances sont à tres-peu prés toutes égales entr'elles, tant sur les Meridiens que sur les Paralleles à l'Equateur: Et quoyque cet Astrolabe soit universel, comme celuy de Gemma Frison & de Rojas, les positions qui sont vers le Centre de l'Astrolabe ne sont pus serrées comme dans celuy de Gemma Frison; & celles qui sont vers les

use on instruments appear to be the pasteboard astrolabes made by Bion himself.

The Rojas astrolabe

Towards the end of the year 1550 ([17]), there was published in Paris a quarto volume of 160 leaves, the title-page of which reads:

> *Illustris uiri D. Ioannis de Roias Commentariorum in Astrolabium, quod Planisphærium vocant, libri sex nunc primùm in lucem editi. His additus est index capitum ac rerum quae toto opere continetur, locupletissimus. Lutetiæ Apud Vascosanum, uia Iacobæa ad insigne Fontis. M. D. L. Cum privilegio.*

The book was illustrated with sixty-three beautifully executed wood-cut diagrams and illustrations of the construction and use of Rojas' astrolabe. Several of the illustrations of figures and buildings had been adapted from wood-cuts used by J. Barbé when he printed Dominique Jacquinot's *L'vsage de l'astrolabe avec vn traicté de la sphere,* in Paris in 1545 ([18]).

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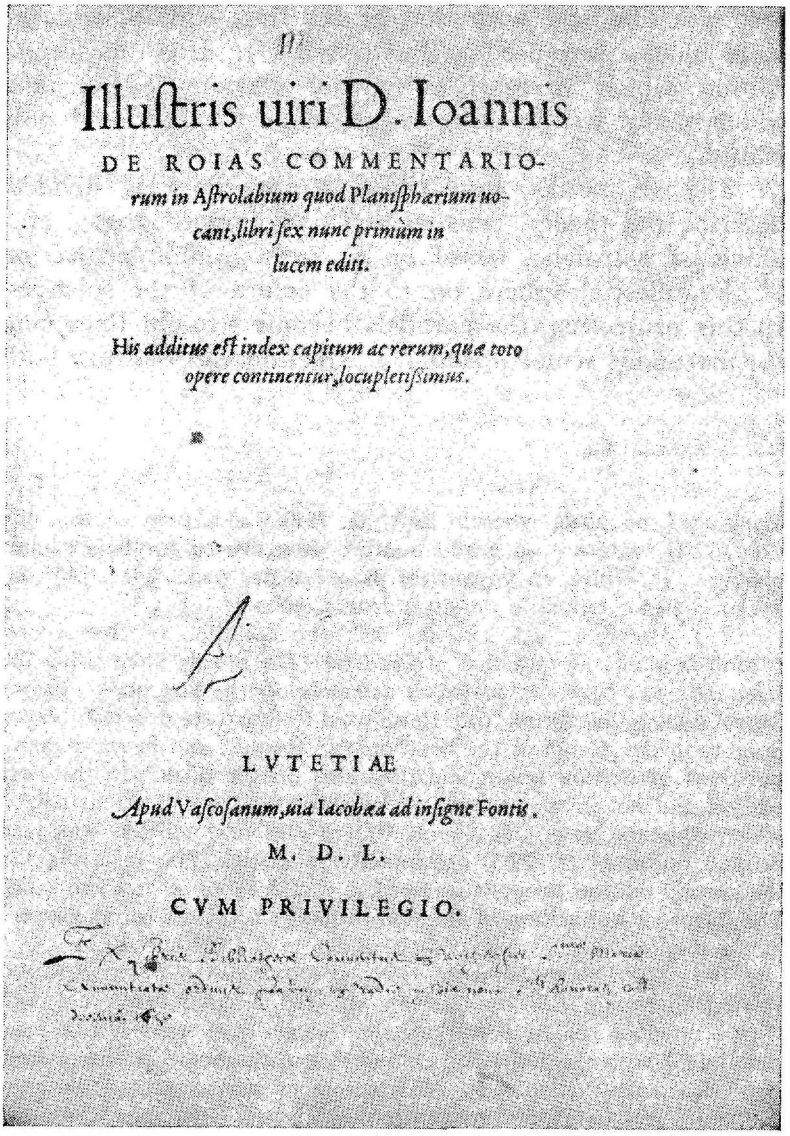
bords ne sont pas plus racourcies que celles du milieu, comme dans celuy de Rojas ce qui y est tres-incommode.

... la maniere de construire l'Astrolabe de Monsieur de la Hire, ... n'est pas plus difficile que celle de l'Astrolabe de Rojas, & ... est plus aisée que celle de Gemma Frison...», *op. cit.*, pp. 21-22.

([17]) The privilege on leaf C4^{v} is dated 'XIII Cal. Septemb. M. D. L.' See Ruth Mortimer, *Harvard College Library. Department of Printing and Graphic Arts. Catalogue of Books and Manuscripts. Part I: French 16th Century Books,* 2 vols., Cambridge (Mass.), 1964, vol. II, p. 567, no. 462. The Harvard College Library copy of the first edition of Rojas' book belonged to the Italian astronomer royal in France, Giovanni Domenico Cassini (1625-1712). Its collation is a-e^{4}, A-Z^{4}, Aa-Ll^{4}, Mm^{6}, Bb^{6} (Mm6 blank). See also Van Ortroy, *op. cit.*, pp. 168-170, who lists several copies.

([18]) Mortimer, *loc. cit.*, and pp. 423-424, no. 328. On a fly-leaf of the copy of the second edition of Rojas' book in the Museum of the History of Science, Oxford, a previous owner has quoted a 'Catalogue des Livres rares et precieux rédigé par M. H.



Illuſtris uiri D. Ioannis

DE ROIAS COMMENTARIO-

rum in Aſtrolabium quod Planiſphærium uo-

cant, libri ſex nunc primùm in

lucem editi.

His additus eſt index capitum ac rerum, quæ toto

opere continentur, locupletiſſimus.

LVTETIAE

Apud Vaſcoſanum, uia Iacobæa ad inſigne Fontis.

M. D. L.

CVM PRIVILEGIO.

Fig. 1: Title-page of the first edition (Paris, 1550) of Juan de Rojas' *Commentariorum in astrolabium... libri sex*, 8° (By permission of the Harvard College Library).

A reset second edition appeared the following year. The text was identical with that of the first edition, and the same blocks were used to illustrate it ([19]). It is this second edition which is most commonly encountered ([20]), and which many writers have regarded as the first and only edition.

The six books, into which Rojas' work is divided, describe the theory, construction and numerous uses of a universal astrolabe, based on an orthographic projection of the celestial sphere on to the colura of the solstices. In this projection, the parallels become straight lines, and the meridians semi-ellipses ([20a]). The intervals between both

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Tron' 1884, no. XXVI, wherein item no. 7540 was a copy of this edition: '... Il renferme un grand nombre de gravures sur bois remarquables. M. Didot, en voyant les planches des pages 196 et 197, en aurait certes attribué le dessin à Jean Cousin...'.

([19]) Mortimer, *op. cit.*, no. 462; the collation of the second edition is identical with that of the first. The blocks illustrating the front and the back of the Rojas astrolabe in the last book (VI) of Rojas' publication differ from those used to illustrate previous books, notably in the design of the head on the 'throne', and in the relative positions of certain scales and diagrams on the back. In the first edition, but not in the second, the block of the back of the astrolabe which appears on p. 282 (book VI) of the first edition was also printed on p. 44 (f. $F2^{v}$), presumably in error. The resetting for the second edition brought forward, *i. a.*, the table on p. 45 to p. 44. The different imposition of the text probably accounts for the errors in the page references given in the index in the second edition.

([20]) The British Museum, *General Catalogue of Printed Books. Photolithographic Edition to 1955*, vol. 205, London, 1963, col. 542, lists a copy of the first edition, and then a copy with a title-page dated 1551 with the following comment: «A duplicate of the preceding, with a new titleplage». This comment has suggested the existence of a reissue of the first edition with a new titlepage (Mortimer, ibid.), but examination of the book shows that it is, in fact, a copy of the second edition. The title-page of the second edition is reproduced by Pereira, *op. cit.*, p. 338.

([20a]) Jonh Blagrave (1558?-1612) who was to prefer Gemma Frisius' projection for his 'Mathematical Jewel', disliked the Rojas projection because it contained 'geometricall crooked lines called Ellipses' (North, *op. cit.*, p. 64).

parallels and meridians become less the farther they are away from the centre of the circular boundary of the projection ([21]).

As shown in Rojas' book, his astrolabe is engraved on one side of a single plate. The meridians are drawn for each hour and subdivided for every twenty minutes. Parallels are drawn only between the tropics (for degrees of the ecliptic) and crossed by an oblique straight line representing the ecliptic. (The marking of the positions of various fixed stars is also envisaged). Pivoted about the centre of the plate, there is a graduated rule on which slides a cursor, at right-angles to the rule (fig. 2) ([22]). On the other side of the plate are scales similar to those usually found on the back of an ordinary astrolabe. These include quadrants graduated in degrees (for measuring altitudes and azimuths), a scale correlating the sun's place in the ecliptic with the date (zodiac/calendar scale), and a shadow-square. There are also a scale of hours, and a sundial recording equal hours. Pivoted about the centre (on the same pin as the rule on the side) is an alidade for use with the scales of degrees in measuring altitudes and azimuths and with the zodiac/calendar scale, shadow-square, and sundial (fig. 3) ([23]).

([21]) See Michel, *op. cit.*, pp. 105-107, 109.

([22]) The procedure for ascertaining the time by the sun, using the Rojas astrolabe, illustrates the principale of operation: the rule is pivoted until it lies on the graduation of degrees on the limb corresponding to the latitude where the instrument is being used (the upper edge of the rule then represents the horizon at that latitude in relation to the celestial sphere depicted on the plate); the cursor is then moved along the rule until a point of the graduation of degrees on the cursor corresponding to the observed altitude of the sun meets the parallel marking the sun's place in the ecliptic on the day of observation; the horary numeration of the meridian closest to the point of intersection of the cursor and the parallel then indicates the time. For details of the method of use of the Rojas astrolabe, and of the similar methods using the *saphaea arzachelis / astrolabum catholicum* of Gemma Frisius, see Michel, *op. cit.*, pp. 109, 99-102.

([23]) For details, see Michel, *op. cit.*, *passim.*

The contents of Rojas' book may be summarized as follows ([24]):

ff. a2[r]-b2[v] — Dedication to the Emperor Charles V.

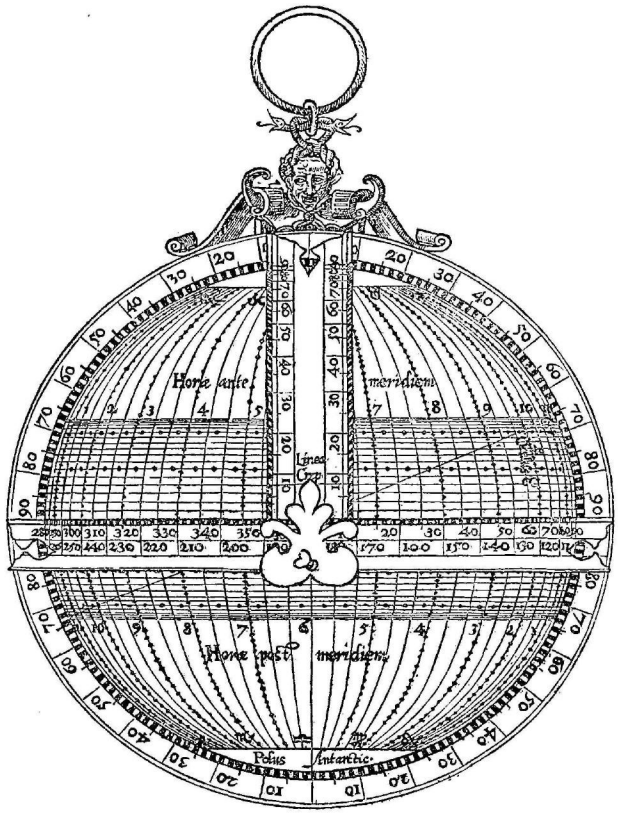

Fig. 2: The front of the Rojas astrolabe, as illustrated in book VI of Rojas' work. (From Rojas, *op. cit.*, 2nd ed., Paris, 1551, p. 278; Museum of the History of Science, Oxford).

([24]) The references here, and subsequently, to Rojas' book are to the second edition of 1551. I have used the copy in the Library of the Museum of the History of Science, Oxford.

b3^{r}-c4^{v} — Table of contents, followed by the privilege.

pp. 1- 40 — 'Libro primo de partibus planisphærii'; seventeen chapters on the celestial sphere and the lines representing it in the projection, with tables of the length of shadow cast by a gnomon and the length of the day, etc., in various regions.

IN PLANISPH. LIB. VI. 281

Posterioris partis planisphærij cum suo indice plena descriptio.

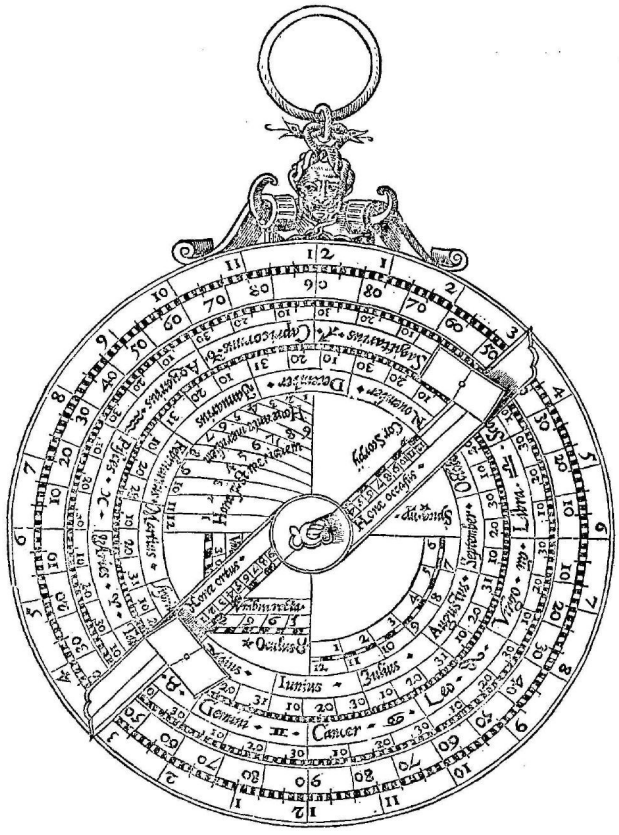

Fig. 3: The back of the Rojas astrolabe, as illustrated in book VI of Rojas' work. (From Rojas, *op. cit.*, p. 281; Museum of the History of Science, Oxford).

pp. 41-125 — 'Libro secundo de usu partium'; preface and sixty chapters on finding declinations and altitudes, risings and settings of the sun and stars, on the construction of sundials, etc., with tables of the altitudes of the zodiacal signs for latitude 42°, including interesting illustrations of sundials.

pp. 125-146 — 'Libro tertio de domibus cœlestibus'; preface and six chapters on the twelve astrological houses and the drawing up of nativities, with a diagram of the nativity of Charles V.

pp. 146-199 — 'Libro quarto de dimensionibus'; preface and twenty-four chapters on the problems of practical geometry, including the use of the shadow-square for finding the length of a shadow cast by the sun, in ascertaining the height of a building, the depth of a well, etc., and the use of the astrolabe as a circumferentor (*i. e.* for finding azimuths) ([25]), with tables of shadow lengths, and of squares and roots from 1 to 662, and several illustrations showing an astrolabe in use for the purposes discussed.

pp. 200-224 — 'Libro quinto de describendis prouinciis'; preface and six chapters on cartography; Rojas quotes extensively from Gemma Frisius' important pioneer work on the uses of triangulation, *Libellus de*

([25]) On the use of astrolabes in this way, and the development of the circumferentor, see Edmond R. Kiely, *Surveying Instruments, their History and Classroom Use*, New York, 1947, *passim;* also Fritz Schmidt, *Geschichte der geodätischen Instrumente und Verfahren im Alterteum und Mittelalter* (Veröffentlichungen der Pfälzischen Gesellschaft zur Förderung der Wissenschaften. vol. XXIV), Neustadt an der Haardt, 1935, *passim.*

locorum describendorum ratione, first published in 1533 ([26]), and reproduces Gemma's diagrams showing methods of triangulation, intercalating his own commentary.

pp. 224-281 — 'Libro sexto de fabrica planisphrærii'; preface and twelve chapters on the construction of a Rojas astrolabe, with tables of solar declination, of right ascensions of the signs, of the sun's place in the ecliptic at approximately five day intervals for the year 1550, and of important stars.

ff. Bb^{r}-Bb6^{r} — Index.

It is the sixth book with which we shall be particularly concerned here. Throughout his work, Rojas shows evidence of very wide reading in the works of classical and later writers, both mathematical and literary. Several classical writers are quoted in Greek. To most quotations, exact references are given. Rojas was concerned with the literary quality of his Latin; in the dedication, he says that he has avoided using terms that are of non-classical origin ([26a]).

The type of astrolabe described by Rojas is generally known to historians of scientific instruments as the 'Rojas astrolabe', and it was known as such to many authors of

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([26]) In *Cosmographicus liber Petri Apiani mathematici, iam denuo integritati restitutus per Gemma Phrysium. Item eiusdem Gemmæ Phrysij Libellus de locorum describendorum ratione, & de eorum distantijs inueniendis...*, Antwerp, 1533. Rojas reproduces the first six capters of the *Libellus.* Gemma Frisius, misunderstanding Rojas' text, thought Rojas had accused him of plagiarising the work of Georg Peurbach; Gemma Frisius, *op. cit.*, f. Cc^{r}. See Van Ortroy, *op. cit.*, pp. 42, 167-170.

([26a]) Rojas, *op. cit.*, b2^{r}: «... In quibus illud unum inter caetera nixi conatíque sumus, ut latino saltem sermone loqueremur. Voculas enim nescio quas, uti Nadir, Zenith, Alidada, Azimuth, Almadarath, Almucantarath, & similia è media ipsa Barbaria deducta, à nostro libro depulimus, atque exterminauimus. In his autem quae latinis

treatises on the astrolabe. However, the projection used in its construction is certainly not Rojas' invention. Neither was he the first to use it on an astrolabe, nor did he lay claim to originality: 'João de Rojas claramente se apresenta como simples expositor e não como inventor' ([27]). In the first book, Rojas remarks that it is difficult to say to whom one owes the type of projection he is about to describe, but that in his day there were many mathematicians who contributed much. He mentions Gemma Frisius, who himself said that he taught the use of the projection described by Rojas ([28]). The projection, in fact, derives from the *Analemma* of Ptolemy ([29]).

Only fragments of the Greek text of Ptolemy's *Analemma* are known to have survived ([30]), but there exists a thir-

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nominibus carebant, à Græcis, sed quæ à probatissimis authoribus recepta sunt, mutuati sumus...».

([27]) Pereira da Silva, *op. cit.*, p. 337.

([28]) Rojas, *op. cit.*, p. 3: «... Cui uero mortalium illud debeamus, non facile dixerim: illud certè scio, in mathematicis doctissimos esse nostra tempestate uiros, qui plurimum in hac re contulerunt. Inter quos Gemma Frisius est, cuius & nos aliquando auditores fuimus, quippe qui hunc nostræ sphæræ colophonem demum (quod auint) addidit...»; quoted and translated by Pereira da Silva, *op. cit.*, p. 337.

Gemma Frisius, *op. cit.*, f. 81^{r}: «Olim cum Louanij auditoribus aliquot nostris familiaribus traderem rudimenta Astronomiæ ac Geometriæ, exposui quoque vsum Planisphærij parallelogrammi. Cuius vsum structuramque eleganter sane descripsit D. Joannes de Rojas»; quoted by Van Ortroy, *op. cit.*, p. 76.

([29]) Bion, *op. cit.*, p. 13, refers to the Rojas astrolabes as «Cet Astrolabe que l'on appelle aussi Analemme...». Pereira da Silva, *op. cit.*, p. 351, mentions that Delambre in 1819 recognised the debt to Ptolemy. The Greek word *analemma* came to be used in several different connotations, especially in gnomonics. Gemma Frisius, *op. cit.*, ff. 8^{v} & 9^{r}, uses the word *analemma* to describe both the projection of his *astrolabum catholicum* and the projection of the Rojas astrolabe; cf. also *ibid.*, ff. 2^{r}, 7^{r}, where Gemma uses the term for an ordinary astrolabe projection and discusses Vitruvius. See also Appendix n. b.

([30]) Biblioteca Ambrosiana, Milan, cod. Gr. L99 sup., now 491, «... palimsesto, qui saeculo VII uulgo tribuitur, sed sine dubio antiquior est» (J. L. Heiberg, *op. cit.*, p. XI).

teenth century translation, by the Flemish Dominican, William of Moerbeke ([31]), from a lost Arabic version. William of Moerbeke's translation was edited, with a commentary, by Federico Commandini and published at Rome in 1562 ([32]). Nothing is known of the Arabic text used by William of Moerbeke, and very little use appears to have been made of this projection in Islam ([33]).

Abû Rayhân al-Bîrûnî (973-after 1050), the great Eastern Islamic scientist ([34]) appears to have devised a similiar projection. In his *Chronology of Ancient Nations* (Sachau's translation), he wrote:

> «Another kind of projection is what I have called the *cylindrical projection* (orthographic projection), which I do not find mentioned by any former mathe-

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([31]) Biblioteca Apostolica Vaticana, cod. Ottobon. lat 1850, 13th cent.; see Heiberg, *ibid.* On William of Moerbeke, see George Sarton, *Introduction to the History of Science*, vol. II, London, 1931, pp. 829-831.

([32]) *Claudii Ptolemaei liber de analemmate, a Fredrico Commandino Urbinate instauratus et commentariis illustratus qui nunc primum eius opera e tenebris in lucem prodit. Eiusdem Fredrici Commandini liber de horologiorum descriptione*, Rome, 1562. The Greek and Latin texts of the *Analemma* were edited from the original manuscripts by Heiberg, *op. cit.*, pp. XI-XII, 187-223. For detailed discussions of the *analemma*, see O. Neugebauer, *The Exact Sciences in Antiquity*, 2nd ed., Providence, 1957 and New York, 1962, pp. 214-218, and Sir Thomas Heath, *A History of Greek Mathematics*, 2 vols., Oxford, 1921, vol. II, pp. 286-292.

([33]) See pp. 215-217 and nn. 47 & 48 below. Only one of the recorded Islamic astrolabes bears an orthographic projection for use as a universal astrolabe. This is an anonymous Persian astrolabe made for the Safavid Shâh Husayn (reigned 1691-1722), now in the Hermitage Museum, Leningrad, no. VC 512. The resemblance to the Rojas astrolabe is so close, that there can be little doubt but that this astrolabe was inspired by Rojas' book, or by a European astrolabe of the Rojas type; it is a rare example of European influence on Islamic astronomical instrument-making.

([34]) See Sarton, *op. cit.*, vol. I, Baltimore, 1927, pp. 707-709; D. J. Boilot, 'L'Œuvre d'al-Beruni. Essai bibliographique', *Institut dominicain d'Études orientales du Caire. Mélanges*, vol. II (1955), pp. 161-255.

matician. It is carried out in this way: You draw through the circles and lines of the globe lines and planes parallel to the axis. So you get in the day-plane straight lines, circles and ellipses (no parabolas or hyperbolas). All this is explained in my book, which gives a complete representation of all possible methods of the construction of the astrolabe» ([35]).

This is not quite as informative as one would wish; in particular, we do not know to what use al-Bîrûnî put his projection, though its use for an astrolabe is certainly implied ([36]). The book to which al-Bîrûnî refers is his *Kitâb fî istî'âb al-wujûh al-mumkina fî san'at al-asturlâb*, of which several manuscripts exist, but which has never been published in full ([37]).

Egnazio Danti (1536-1586), of the Dominican order, cosmographer to Pope Gregory XIII ([38]) included a detai-

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([36]) Edward Sachau (transl. & ed.), *The Chronology of Ancient Nations. An English Version of the Arabic Text of the Athâr-ul-Bâkiya of Albîrûnî, or «Vestiges of the Past», collected and reduced to writing by the author in A. H. 390-1, A. D. 1000*, London, 1879, pp. 357--358. The passage quoted occurs in a special section on projections and the construction of celestial and terrestrial maps, which al-Bîrûnî, «not knowing any special treatise on this subject», added to his chapter (XXXI) on the lunar stations.

([36]) Hartner, *op. cit.*, p. 725 remarks, «Other planispherical astrolabes based on other projections than the stereographic are to be regarded as theoretical constructions without practical significance, e. g. the astrolabe devised by al-Bîrûnî and called *ustuwânî*, because of its projection (Ptolemy's «Analemma»), which al-Bîrûnî called cylindrical, and which we now call orthographic...».

([37]) For a list of manuscripts, and of published accounts or of extracts from this work, see Boilot, *op. cit.*, pp. 191-192.

([38]) On Danti, see Iodoco del Badia, *Egnazio Danti, cosmografo e matematico, e le sue opere in Firenze, Memoria storica*, Florence, 1881 (repr. from *Rassegna nazionale*, vol. VI, 1 settembre, and vol. VII, 1 novembre, 1881); Michel, *op. cit.*, p. 167.

According to Felipe Picatoste y Rodriguez, *Apuntes para una biblioteca científica española del siglo XVI. Estudios biográficos y bibliográficos de ciencias exactas, físicas y naturales y sus inmediatas aplicaciones en dicho siglo*, Madrid, 1891, p. 274, «... el matemático italiano Ignazio Danti... se aprovechó de las lecciones de Rojas para trazar la meridiana en Florencia y Bolonia...».

led account of the Rojas astrolabe in his *Trattato dell'uso et della fabbrica dell'astrolabio*, first published in Florence in 1568. Danti recognized that neither the *astrolabum catholicum* of Gemma Frisius, nor the astrolabe of Juan de Rojas were inventions of the sixteenth century (39). He goes on to say:

> «Il Roias... trasse la maggior parte del suo Planisferro, da gl'Arabi massimamente de vn libro di strumenti qua le Alfonso Re di Spagna d'Arabe, & Caldeo tradusse in Castigliana lingua, & hor di Castigliana lingua, mutato è già gran tempo in volgar fiorentino che appresso di me si tiene» (40).

The work here referred to, and of which Danti had by him an Italian translation is, of course, the *Libros del saber de astronomía* of Alfonso X, el sabio (41).

The reference to the *Libros del saber* is clearly to the 'Libro de la açafeha', (42)

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(39) Danti, *op. cit.*, pp. 140-141.

(40) *Ibid.*, p. 141. Martín Fernández Navarrete, *Disertación sobre la história de la náutica*, Madrid, 1846, p. 201, says of Rojas' book; «... obra en que acreditó sus conocimientos matemáticos, sin embargo de haberse aprovechado en mucha parte de las escritos árabes, y especialmente de un libro de instrumentos que de la lengua árabe tradujo á la castellana el Rey D. Alonso [*sic*] el Sabio...». Is this a paraphrase of Danti? Fernández Navarrete's book was not available to me, and I have used Pereira da Silva's quotation therefrom, *op. cit.*, p. 335-6.

(41) See n. 10 above. It is possible that the Italian translation to which Danti refers is that made in 1341 by Guerniccio di Cione Federighi whose manuscript is now in the Bibliotheca Apostolica Vaticana cod. 8174. The history of this manuscript before 1612 is not known; see Enrico Narducci, *Intorno ad una traduzione italiana fatta nell'anno 1341 di una compliazione astronomica di Alfonso X. re di Castiglia*, Rome 1865; Silvio A. Bedini, 'The Compartmented Cylindrical Clepsydra', *Technology and Culture*, vol. III, no. 2 (Spring 1962), p. 118 and fig. 1; and Pierre Knecht, *I Libri astronomici di Alfonso X in una versione fiorentina del trecento. Tesi di laurea presentata alla Facoltà di lettere dell'Università di Zurigo*, Zaragoza, 1965.

(42) Pereira da Silva, *op. cit.*, p. 351; Rico y Sinobas, *op. cit.*, vol. III, pp. 133-237.

«que fizo Azarquiel. el sabio astrolomiano de Toledo... Et despues fue á Sevilla. et fizo esta açafeha mesma en otra manera mas complida et mas acabada. Et fizo otrossí el libro de cuemo de deue fazer. et de

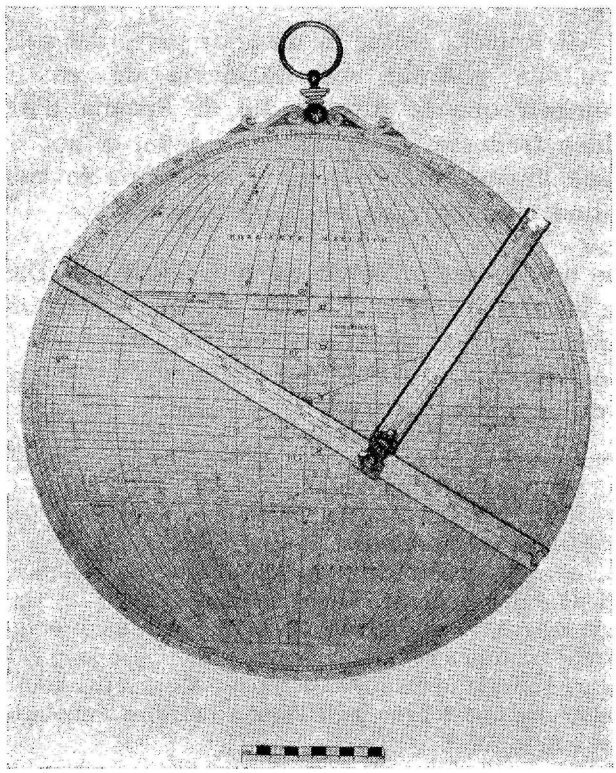

Fig. 4: A Rojas astrolabe on the back of an ordinary astrolabe made in Florence, *c.* 1580, by Egnazio Danti; brass, diam. *c.* 400 mm. (Museum of the History of Science, Oxford, n. IC 180).

cuemo deuen obrar por ella... Et este libro sobredicho trasladó de aráuigo en romançe maestre Fernando de Toledo por mandado del muy noble rey don Alphonso... en el anno quarto que él regnó. Et despues mandólo trasladar otra uez en Burgos meíor et mas complidamientre á maestre Bernaldo el aráuigo. et á don Abra-

hem su alfaquí. en el. XXVI. anno del so regno [= 1277 A. D.]...» ([43]).

The front of the instrument described in this book of the *Libros del saber* is engraved with the stereographic projection of the *saphaea arzachelis* ([44]). The back ([45]) however, bears within a scale of degrees and zodiac/calendar scale, a very interesting circular diagram. One quadrant of the diagram is ruled sexagesimally with lines giving the sines of the angles shown on the scale of degrees ([46]). The other three quadrants contain a series of semi-ellipses, or parts thereof, superficially similar to the meridians in an orthographic projection of the celestial sphere. The major axis of these ellipses is crossed by a series of straight lines, originating at regular intervals of the surrounding circular scale of degrees (as they would if they represented latitudes). These lines, therefore, become closer together the further they are from the centre of the circular boundary of the diagram ([47]). The semi-

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([43]) Rico y Sinobas, *op. cit.*, vol. III, p. 135.

([44]) See above, pp. 5-7; Rico y Sinobas, *op. cit.*, vol. III, plate facing p. 148.

([45]) Rico y Sinobas, *op. cit.*, vol. III, plate entitled, 'Esta es la figura de las espaldas de la Lamina', preceding p. 149. There also exists a less complicated form of the *saphaea arzachelis* (this term, and variants of it, are applied not only to the stereographic projection on the front of this plate, but also to include what is on the back) with a back similar to that on an ordinary astrolabe; see Millás Vallicrosa, *op. cit.*, chapter IX, especially p. 449.

([46]) What Michel calls the 'graphique des sinus'; see *op. cit.*, p. 40.

([47]) A closely related diagram is found on the back of an astrolabe made in Seville in 609 A. H. (1212/3 A. D.) by Muhammad b. Fattuh al-Khamâ'irî, described by H. Sauvaire and J. de Rey Pailhade, 'Sur une *mère* d'astrolabe arabe du XIII[e] siècle (609 de l'hégire) portant un calendrier perpétuel avec correspondance musulmane et chrétienne. Traduction et intérpretation', *Journal asiatique*, 9[e] sér, vol. I (1893), pp. 5-76, 185-231. Other astrolabes by Muhammad b. Fattuh also have similar diagrams; for a list of some of his instruments, see L. A. Mayer, *Islamic Astrolabists and their Works*, Geneva, 1956, pp. 64-66. The diagram, exactly as found in the 'Libro de la açafeha', is seen on another *saphaea arzachelis*, made in Murcia

-ellipses, however, are equally spaced ([48]), so they cannot, as on the Rojas astrolabe, represent meridians which are spaced on the celestial sphere at equal angular intervals and which, therefore, in orthographic projection, become closer together towards the boundary of the containing circle. In fact, they are ellipses of which the semi-axes minor represent $\frac{5}{60}, \frac{10}{60}, \frac{15}{60} \ldots \frac{60}{60}$ of the radius of the containing circle. A given ellipse, passing through a point P of the sexagesimal division of the diameter, *could* be considered as an orthographic projection of a circle, of the same radius as the containing circle, inclined to this circle at an angle χ, such that $\chi = \text{arc cos } \frac{P}{60}$ ([49]). The angle χ can be found by use of the sine diagram in the fourth quadrant.

Although these ellipses and 'parallels' can be considered as orthographic projections, it is questionable whether they should be regarded as an astrolabe, or even as constituting an orthographic projection of the celestial sphere. The

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in 650 A. H. (1252/3 A. D.) by Muhammad b. Muhammad b. Hudhayl, now in the museum of the Real Academia de Ciencias y Artes de Barcelona in the Observatorio Fabra, Barcelona; see José M. Millás Vallicrosa, 'Un ejemplar de azafea árabe de Azarquiel', *Al-Andalus*, vol. IX (1944), pp. 111-119, and Mayer, *op. cit.*, p. 773.

([48]) In the 'Libro de la açafeha' and on Muhammad b. Muhammad b. Hudhayl's astrolabe (n. 47, above), the semi-elipses divide the diameter of the circular boundary of the diagram into 24 equal divisions; on Muhammad b. Fattuh's astrolabe (n. 47, above) they divide the semi-diameter into 10 equal divisions. In the examples mentioned, there are also variations in the drawing of the straight lines ('parallels'). In the 'Libro de la açafeha', these lines are to correspond to 5° intervals of the arc; Rico y Sinobas, *op. cit.*, vol. III, p. 142. The illustration on p. 143 shows these lines correctly drawn, but for 10° intervals, but the large plate, preceding p. 149, is inaccurately drawn. Muhammad b. Muhammad's astrolabe has the lines drawn for 5° intervals. Muhammad b. Fattuh, however, has chosen to superimpose on the ellipses a continuation of the sexagesimal sine diagram.

([49]) *cf.* Sauvaire and Rey Pailhade, *op. cit.*, pp. 202-3.

ellipses result inevitably from the method of construction ([50]), and rather than rashly assuming that the author of the 'Libro de la açafeha' was consciously using orthographic projection, it might be preferable to regard the diagram as a purely trigonometric device for the solution of certain astronomical problems. However, in assessing the possible influence of this diagram on the Rojas astrolabe, it should be remembered that some of the problems, for the solution of which the author of the 'Libro de la açafeha' uses his diagram, are what might be termed 'astrolabic', though neither the ecliptic nor any fixed stars are marked. Furthermore, the diagram is used in conjunction with a pivoted rule, equipped with a cursor, just as in the Rojas astrolabe ([51]). A detailed and careful study of the 'Libro de la açafeha' and, indeed, of the whole of the text of the *Libros del saber* is urgently needed.

Written in a vernacular, the *Libros del saber* appear to have had, outside the Iberian peninsula, a narrower diffusion and less influence than had they been written in Latin ([52]). Nevertheless, Rojas certainly knew the *Libros del saber* ([53]). For his acquaintance with the theory of orthographic projection, however, there are possible sources other than contemplation of the diagram on the back of the *saphaea arzachelis*. Rojas, as we have seen ([54]), sug-

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([50]) Rico y Sinobas, *op. cit.*, vol. III, p. 142. Lines joining corresponding points, dividing the diameter, and the 'parallels' between equal intervals of arc, into equal numbers of divisions are ellipses. It should, however, be borne on mind that the author of the 'Libro de la açafeha' would have had little use for the equal hour meridians of the Rojas astrolabe.

([51]) See the illustration in Rico y Sinobas, *op. cit.*, vol. III, p. 145, and the description on pp. 143-144.

([52]) Procter, 'Scientific Works...', p. 28. The Alfonsine Tables, however, were well known, because they were modified at Paris in the early part of the fourteenth century; *ibid.*, p. 13.

([53]) Rojas mentions the 'Libro de la açafeha', *op. cit.*, p. 131; other references to the *Libros del saber*, or to Alfonso X, occur on pp. 43, 130, 132. Gemma Frisius' revival of the *saphaea arzachelis* as his *astrolabum catholicum* (see above p. 6), may also derive from familiarity with the *Libros del saber*.

([54]) pp. 15-16 above, and n. 28.

gests a certain currency of ideas on this subject. Perhaps the translation of Ptolemy's *Analemma* by William of Moebeke was generally known to mathematicians and astronomers of late medieval Europe, and to Gemma Frisius and his pupils at Louvain in the sixteenth century. Ptolemy's *Analemma* was of use in the construction of sundials ([55]), and an *analemma* is discussed in this context by Vitruvius in book IX, 7 of his *De Architectura* ([56]). The *editio princeps, c.* 1486, of the *De Architectura* was followed by many other editions, both in Latin and vernacular, some of which were illustrated and included detailed commentaries ([57]).

So little, indeed, is at present known with certainty of the medieval diffusion of texts describing scientific instruments and relevant theory, and so very many manuscripts remain to be studied, that it is practically impossible to trace in any detail the history of any medieval scientific

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([55]) Commandini (see above n. 32) was to append a treatise on sundials ('Liber de horologiorum descriptione') to his edition of the *Analemma*.

([56]) F. Krohn (ed.), *Vitruvii de architectura libri decem* (Bibliotheca scriptorum graecorum et romanorum Teubneriana), Leipzig, 1912, pp. 215-217; Auguste Choisy (trans. & ed.), Vitruve, 4 vols., Paris, 1909, vol. I, pp. 264-265, vol. III, pp. 149-153, vol. IV, pl. 75.

([57]) See Zoubov, *op. cit.*, p. 84, n. 1; also Sarton, *op. cit.*, vol. I, Baltimore, 1927, pp. 223-224. For an elaborate commentary on book IX of the *De Architectura*, using Commandini's treatise (n. 54, above), see the 2nd edition of Daniele Barbaro's Italian translation, *I Dieci Libri dell' Architectura di M. Vitruvio*, Venice, 1567; the illustrative diagrams are excellent.

An examination of the vast literature on dialling which was produced in the late fifteenth and early sixteenth centuries might reveal hitherto unrecorded uses of the *analemma*. Curiously, neither Sebastian Munster's *Horologiographia*, Basle, 1533 (the first edition in 1531 of this work bears a different title, see Zoubov, *op. cit.*, p. 85, n. 12), nor Orontius Fineus' 'De solaribus horologiis, et quadrantibus, libri IIII', included in his *Protomathesis: opus varium...*, Paris, 1532, both famous works of the period, appear to contain any reference to the *analemma*. Fineus, however, certainly knew of the form of stereographic projection used later in Gemma Frisius' *astrolabum catholicum*, for the same net appears, *op. cit.*, f. 155^{v}, in the section, 'De cosmographia'.

instrument. We can, therefore, do no more at present than conclude this account of the Rojas astrolabe by recording the existence of a few instruments of earlier date than the publication of Rojas' book, which nevertheless use the orthographic projection described by him:

a) In the National Maritime Museum, Greenwich, there is an ordinary planispheric astrolabe, dated 1462, on the back of which, on a rotatable disc, is an orthographic projection of the celestial sphere, constituting a universal astrolabe, which is similiar, if somewhat simpler, than that described by Rojas. The signature on this astrolabe has been interpreted as that of Regiomontanus ([58]); the style of the *rete* of the ordinary astrolabe on the front is strongly reminiscent of the work of Georg Hartmann (1489-1564), of Nuremberg ([59]), who may well have been inspired by the tradition which this astrolabe represents.

b) In the Muzeum Universytetu Jagiellonskiego, in the Collegium Maius, at Cracow, there is a celestial globe surmounted by an astrolabe which bears on one side a stereographic projection of the twelve astrological houses below a *rete* showing the ecliptic

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([58]) D. J. de S. Price, 'The First Scientific Instrument of the Renaissance', *Physis. Rivista di storia della scienza*, vol. I (1959), fasc. 1, pp. 26-30. The form of the projection on this astrolabe is close to that found on a number of sixteenth and seventeenth century astronomical *compendia*, quadrants, and nocturnals (all later than Rojas' book) where it serves as a sundial. A nocturnal of this type was described by Pereira da Silva, 'Um Astrolábio do século XVII', *Lusitania*, vol. III (1925-26), pp. 409-416, reprinted in *Obras completas...*, vol. III, pp. 301-311; see also Kathleen Higgins, 'The Classification of Sundials', *Annals of Science*, vol. IX, no. 4 (December 1953), p. 347, who calls this type of dial, 'Geminus dial', after the example made in Rome in 1589 by Antonius Geminus, now in the Museum of the History of Science, Oxford, no. I. 30. See also the Appendix of this article.

([59]) See Ernst Zinner, *Deutsche und niederländische astronomischen Instrumente des 11.-18. Jahrhunderts*, Munich, 1958, pp. 357-368.

only, and on the other side an orthographic universal astrolabe. This instrument is dated 1480 and, though anonymous, is known to be the work of Hans Dorn of Vienna, who made it for the eminent astronomer and mathematician, Marcin Bylica of Olkusz ([60]).

c) In the Museo di Storia della Scienza, Florence, there is an anonymous ordinary astrolabe (no. IC 492), dated 1483, with an orthographic universal astrolabe on a disc set in the back, which is similar to that on *a)* above. This astrolabe is almost certainly the work of Hans Dorn of Vienna.

d) A small astronomical manuscript (present location unknown), almost certainly dating from 1546, includes among its diagrams an orthographic projection of the celestial sphere ([61]).

Juan de Rojas Sarmiento

From Juan de Rojas' book on his astrolabe, it is possible to ascertain a few scraps of information about his life. To this scanty material, a little may be added from other published sources, but he still remains an elusive figure among the scientific writers of the sixteenth century.

The name of Rojas ([62]) is not uncommon, but the important family to which Juan de Rojas belonged can be

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([60]) See Maria N. Zakrzewska, *Catalogue of Globes in the Jagellonian University Museum*, Cracow, 1965, pp. 7-8; also Zofia Ameisenowa, *The Globe of Marcin Bylica of Olkusz and Celestial Maps in the East and the West* (Polska Akademia Nauk. Komitet Historii Nauki. Monografie z dziejów nauki i techniki, vol. IX), Wroclaw, Cracow and Warsaw, 1959; Tadeusz Przypkowski, 'Les premières cartes modernes du ciel', *Archives internationales d'histoire sciences*, 15e année, nos. 58-59 (janvier-juin 1962), pp. 146-9; Zinner, *op. cit.*, pp. 292-297.

([61]) The manuscript was offered for sale in November 1962 by Alain Brieux, Paris; see Emmanuel Poulle and Francis Maddison, 'Un Équatoire de Franciscus Sarzosius', *Physis. Rivista de storia della scienza*, vol. V (1963), fasc. 1, p. 16, n. 16.

([62]) Formerly also spelt Roxas, or Roias.

traced back to the twelfth century (63). «Vna de las nobilissimas y antiguas familias que hallamos en estos Reynos es la de Rojas, tan ilustre y conocida en ellos, quanto a todos es notorio, y escriuen los Cronistas dellos», wrote Alonso Lopez de Haro in the seventeenth century (64). A certain Diego Sánchez, said to be the first of the name of Rojas «por el señorío que tuvo en aquella villa», was *mayordomo mayor* to King Alfonso VIII (65) of Castille (1158-1214), the founder at Palencia of the first Spanish *studium generale.* Here, we may ignore the subsequent history of the various branches of the family, and begin again with Diego de Rojas, the grandfather of Juan de Rojas. Diego de Rojas, *señor* of Monzón (de Campos) and Cabia, married Elvira de Rojas, *señora* of Poza (de la Sal) «restituyendo á este casa la antigua varonía de Rojas» (66). Their eldest son, Juan de Rojas, Señor de Poza, Monzón y Cabia, became the first Marqués de Poza: «... fue Cauallero generoso en seruicio del Emperador don Carlos (67),

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(63) Luís Vitar y Pascual, *Diccionario histórico, genealógico y heráldico de las familias ilustres de la monarquía española,* vol. VIII (2nd ed.), Madrid, 1866, p. 129.

(64) Alonso López de Haro, *Nobiliario genealogico de los reyes y titulos de España,* Madrid, 1622, 2ª parte, lib. x, cap. xx, p. 366 (wrongly numbered 356).

(65) Vilar y Pascual, *ibid.* The village of Rojas is situated in the province of Burgos, latitude 42.35 N, longitude 3.26 W, *c.* 35 km. NE of Burgos.

(66) *Op. cit.*, p. 133. See the genealogical tree reproduced as fig. 5. Monzón de Campos is situated in the province of Palencia, latitude 42.07 N, longitude 4.29 W, *c.* 10 km. N. of Palencia. The latitude Rojas gave for his father's home (see n. 73, below) would suggest rather Monzón in the province of Huesca, latitude 41.54 N, longitude 0.12 E, *c.* 44 km. SE of Huesca, but a remark in the book by Hugo Helt discussed below, pp. 37 ff., f. 23r, makes it certain that Rojas' father lived at Monzón de Campos, near Valdespina and Palencia. Cabia is in the province of Burgos, latitude 42.17 N, longitude 3.51 W, *c.* 10 km. SW of Burgos. Poza de la Sal is also in the province of Burgos, latitude 42.40 N, longitude 3.30 W, *c.* 40 km. NE of Burgos.

(67) Charles V (1500-1558), Charles I of Spain 1516-1556, Holy Roman Emperor 1519-1556.

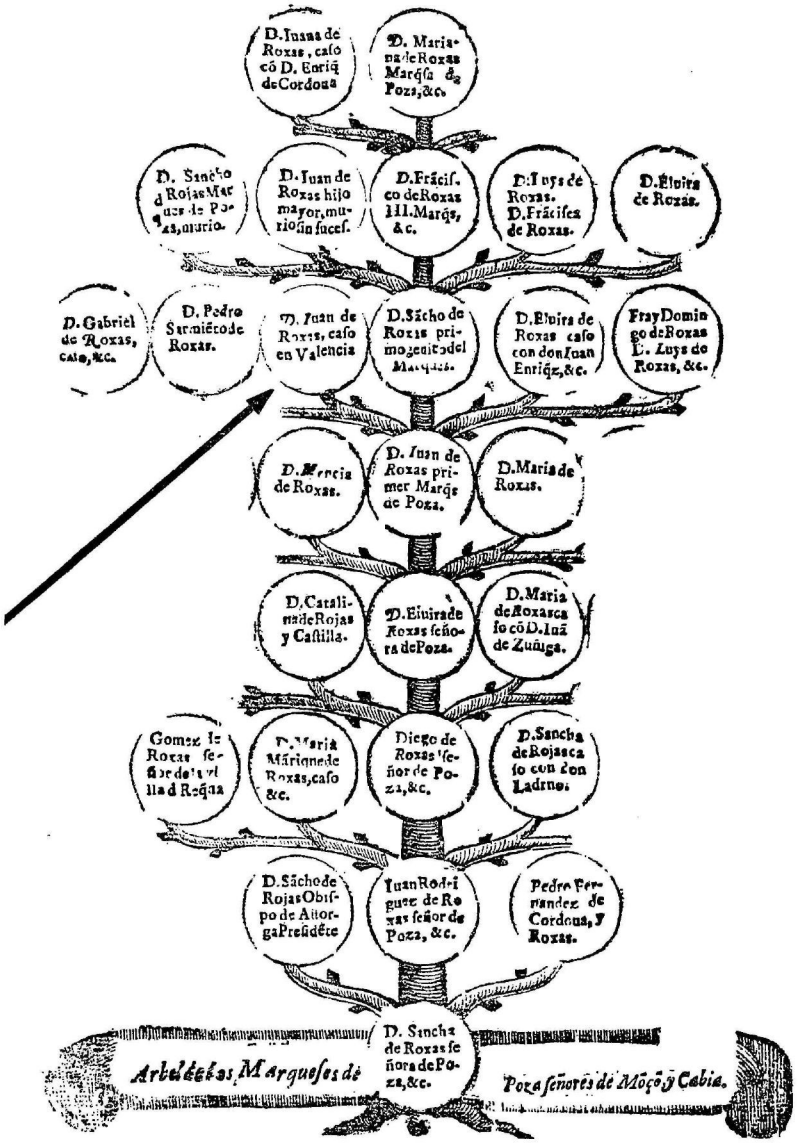

Fig. 5: A genealogical tree of the Rojas family, from Alonso López de Haro, *Nobiliario genealogico de los reyes y titulos de España*, Madrid, 1622, 2ª parte, p. 372. Juan de Rojas Sarmiento is indicated by the arrow. (By courtesy of the Curators of the Bodleian Library, Oxford).

como lo mostro en todas las ocasiones que se ofrecieron, y assi le honrò de su mano con el Titulo benemerito de Marques de Poza...» ([68]). By his marriage to Marina Sarmiento, daughter of Diego Gómez Sarmiento, Conde de Salinas y Rivadeo, he had several children, of whom six sons and a daughter are recorded ([69]). The eldest son, Sancho, died during the lifetime of his father and the marquisate passed to his son, also called Sancho. Two of the brothers entered the Church: Luís who became a priest, and Domingo who became a friar ([70]). The daughter, Elvira, married Juan Enriquez de Almansa, second Marqués de Alcañices ([71]), whose sister, Francisca Enriquez de Almansa, married Elvira's brother Sancho ([72]).

Juan de Rojas Sarmiento was the second son of the first Marqués de Poza ([73]). As a young man, it was said, he so applied himself to liberal studies that he was already marked out for a bishopric ([74]). He went to the Nether-

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([68]) López de Haro, *op. cit.*, 2ª parte, p. 367.

([69]) *Ibid.*, see also Vilar y Pascual, *op. cit.*, p. 133.

([70]) Vilar y Pascual, *ibid.*

([71]) *Ibid.*, see below.

([72]) López de Haro, *op. cit.*, 2ª parte, p. 356.

([73]) Rojas, *op. cit.*, p. 61, mentions his father: «Fingamus igitur apud Mouzon [*sic*, recte «Monzon», vide *op. cit.*, index, f. b4ᵛ] ulterioris Hispaniæ nos esse, ubi in præsentia commoramur, quod nunc oppidum Marchinoni de Poza patri meo paret (hoc Attacum olim dictum, nescio an uerè, nonnulli affirmant) ubi per 41. cum dimidio ferè, gradus polus eleuatur»; *cf.* Van Ortroy, *op. cit.*, p. 169, n. 2.

([74]) «... studiis liberalibus ita inuenis incubuit, vt iam episcopatui destinaretur», [Andreas Schottus,] *Hispaniæ bibliotheca seu de academiis ac bibliothecis. Item elogia et nomenclator clarorum Hispaniæ scriptorum, qui Latine disciplinas omnes illustrarunt philologicæ philosophicæ medicinæ iurisprudentiæ, ac theologiæ tomis III distincta*, Frankfurt, 1608, 'Tertia classis castellaronum seu carpetanorum', p. 576; the origin of this statement may well be found in the work of one of the several authors listed by Schottus at the outset of his book, but I have not been able to trace it. Schottus' note on Juan de Rojas is paraphrased by Nicolò Antonio, *Bibliotheca Hispana sive hispanorum, qui usquam unquamve sive Latinâ sive populari sive aliâ quâvis linguâ scriptio aliquid consignaverunt noticia, his quæ æcesserunt locupletior et certior brevia elogia, editorum atque*

lands with the Emperor Charles V and Prince Philip ([75]). Staying in Louvain, he took lessons from Gemma Frisius ([76]), though probably not as a formal student of the University in that city. Gemma Frisius was Professor of Medicine at Louvain and taught mathematics and astronomy in his own house ([77]). While Rojas was in Louvain, his brotehr-in-law, the Marqués de Alcañices died ([77a]). On this occasion, he was moved to write a consolatory piece to his sister which was published at Louvain in 1544. The title-page of this publications reads as follows:

> *Oracion consolatoria que Don Ioan de Roias Sarmiẽto escribio ala muy ilustre Señora Dõna Eluira de Roias su hermana Marquessa de Alcannizas. Con prefacion del Señor Don Christoual de Roias. Fue impresa en Louayna por Rutgero Rescio. Año de 1544.* ([78])

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ineditorum operum catalogum duabus partibus continens, quarum hæc ordine quidem rei posterior, conceptu verò prior duobus tomis de his agit, qui post annum secularum MD. usque ad præsentem diem floruere, 2 vols, Rome, 1672, vol. I, p. 591; also in the revised edition, *Bibliotheca hispana nova...*, 2 vols., Madrid, 1783-8, vol. I, p. 772.

([75]) Schottus, *ibid.*

([76]) *Ibid.*; we also have Rojas own statement to this effect: «Gemma Frisius... cuius & nos aliquando auditores fuimus...»; see above, n. 28.

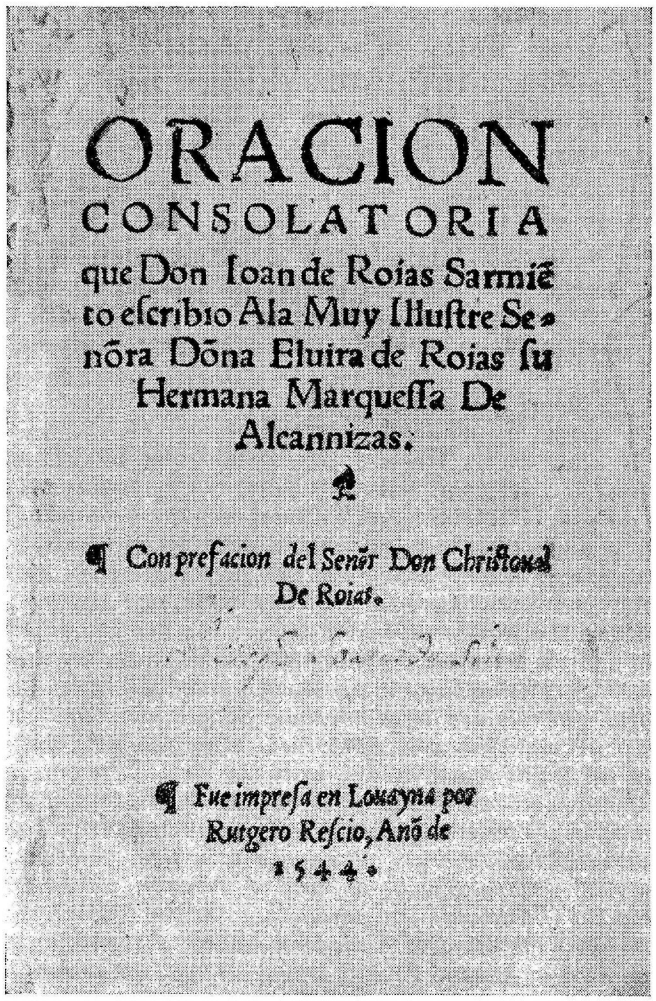
([77]) *Cf.* Van Ortroy, *op. cit.*, pp. 30-32.

([77a]) Rojas, *Oración consolatoria...* (see pp. 30-31 below), f. A3[v] (preface by Cristóbal de Rojas).

([78]) See J.-F. Peeters-Fontainas, *Bibliographie des impressions espagnoles des Pays-Bas méridionaux*, 2 vols., Niewkoop, 1965, no. 1138. This book by Rojas is extremely rare. The only copy I have been able to trace belongs to the Hispanic Society of America; see Clara Louisa Penney, *Printed Books 1468-1700 in the Hispanic Society of America*, New York, 1965, p. 478. This copy was bought at Lisbon in 1841 by T. Norton; in 8°, its collation is A[8]-H[8] (A7[v] and H8[v] are blank); (private communication form Miss C. L. Penney, 2 December 1965).

Antonio, *ibid.*, noted the existence of this work: «Vidimus quoque Hispanum docti viri opusculum, cujus hæc nota, Oracion consolatoria... Commendatur hæc Latinis elegantibus epigrammatis Ioannis Verzosaæ, Francisci Gratiani Toletani, atque Alphonsià Mendoza Augustiniani scriptis suis sat noti».

Rojas then appears to have returned to Spain where he wrote the book on the universal astrolabe, published in Paris in 1550. According to the dedicatory preface to



ORACION
CONSOLATORIA
que Don Ioan de Roias Sarmiẽ
to eſcribio Ala Muy Illuſtre Se-
nõra Dõna Eluira de Roias ſu
Hermana Marqueſſa De
Alcannizas.

¶ Con prefacion del Señor Don Chriſtoual
De Roias.

¶ Fue impreſa en Louayna por
Rutgero Reſcio, Anõ de
1544.

Fig. 6: The title page of Juan de Rojas' *Oración consolatoria...*, written to his sister Elvira de Rojas on the death of her husband, the Marqués de Alcañizas, and published in Louvain in 1544, 8°. (In the Library of the Hispanic Society of America).

Charles V, Rojas had promised the Emperor, in Louvain, that he would write such a book, but had been prevented by ill health from doing so ([79]). From a later passage ([80]), it appears that he wrote it at his father's home in Monzón. The occurrence of the dates 1545 and 1546 in certain examples of problems given in the text ([81]), suggest that Rojas was back in Spain about that time.

Thereafter, Rojas seems to have abandoned his scientific pursuits and to have «borne arms, after the manner of courtiers» ([82]). He married in Valencia, but we know nothing about his wife, or their children whose existence

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([79]) Rojas, *Astrolabium*, f. b2^{r}: «Promiseram iam olim tibi cum Louanij essem aduersam ualetudinem, qua tunc temporis eo usque laboraui, ut exanimis fere in patriam redire coactus sim, hucúsq; promissum persoluere nobis non licuit»; Van Ortroy, *op. cit.*, p. 169, n. 2.

([80]) Quoted above, p. 28, n. 73.

([81]) Rojas, *op. cit.*, e. g. pp. 45, 54, 62.

([82]) «Post arma tractare cœpit aulicorum more», Schottus, *ibid.*; see also Antonio, *ibid.* Picatoste y Rodríguez exaggerates when, *op. cit.*, p. 274, he refers to Rojas as «uno de aquellos nobles que en el siglo XVI no se desdeñaron de dedicarse exclusivamente á las ciencias, ejemplo dignísimo que no imitaron sus sucesores». The only publications which Rojas is certainly known to have written are the works mentioned above: the item of *belles lettres* of 1544 and the scientific book of 1550. Other works have, however, been wrongly attributed to him. *Ministère de l'Éducation nationale. Catalogue générale des livres imprimés de la Bibliothèque nationale*, vol. CLIV, Paris, 1959, cols. 844-5, lists after the first and second editions of Rojas' book on the astrolabe, an ... *Epitome omnium successionibus ex testamento et ab intestato jure communi, & regio*, published in a collection, Venice, 1584, an ... *Opus tripartitum: De successionibus, de hereticis, et singularia in fidei fauorem...*, Salamanca, 1581, and a *Singularia iuris in fauorem fidei haerisisque detestationem, tractatus de haereticis...*, Venice, 1583. The second of these works is listed with the first edition of the Rojas' book on the astrolabe in Antonio Palau y Dulcet, *Manual del librero hispano-americano*, vol. 6, Barcelona and London, 1926, p. 326. All three works are by another Juan de Rojas, who was Bishop of Agrigento in Sicily, as Schottus well knew, *ibid.*: «Alter quoque Ioannes Roias Agrigentinus Episcopus...»; see also Louis Moréri, *Le Grand Dictionnaire historique, ou le mêlange curieux de l'histoire sacrée et profane...* (new ed. by Drouet), vol. IX, Paris, 1759, p. 311.

only is recorded ([83]). He is said to have died on a journey to Thrace ([84]), an ill-defined area of the Balkans of which Camões was soon to write:

Entre o remoto Istro e o claro Estreito
Aonde Hele deixou, co nome, a vida,
Estão os Traces de robusto peito,
Do fero Marte pátria tão querida
Onde, co Hemo, o Ródope sujeito
Ao Otomano está, que sometida
Bizântico tem a seu serviço indino.
Boa injúria do grande Constantino! ([85])

Why Rojas should have set out for Thrace can only be a subject of speculation. Perhaps he went to join one of the campaigns against the Turkish invader, whose presence weighed so heavily on the minds of men in the sixteenth century ([86]). The last item of information we have concerning Rojas is that he left, at his death, a library very well furnished with books, in particular with manuscripts ([87]).

Hugo Helt, Frisius

Only Luciano Pereira da Silva seems to have noticed ([88]) that the sixth book of Rojas' *Commentariorum in astrola-*

([83]) «Valentiæ vxorem duxisse putatur», Schottus, *ibid.*; «... caso en Valencia y dexò hijos», López de Haro, *op. cit.*, 2ª parte, p. 367; «Valentiæque in reditu uxorem duxit», Antonio, *ibid.*

([84]) «Quidam in Thraciam profectum periisse commemorant», Schottus, *ibid.;* an identical sentence in Antonio, *ibid.*

([85]) *Os Lusíadas*, Canto III, 12.

([86]) See, for example, Sydney H. Moore, 'The Turkish Menace in the Sixteenth Century', *The Modern Language Review*, vol. XL, no. 1 (January 1945), pp. 30-36.

([87]) «Instructissimam libris Bibliothecam reliquit præsertim M. S.», Schottus, *ibid.*; Antonio, *ibid.*, Monsieur Marcel Destombes of Paris possesses a copy of Guillaume Portell, *De Magistratibus atheniensum liber...*, Basle, 1543, which is inscribed with the name 'Don Juan de Rojas', probably in Rojas' hand. This is the only work known to me which belonged to Rojas.

([88]) Pereira da Silva, 'O Astrolábio universal...', *passim.*

bium... libri sex... is the work of a certain Hugo Helt ([89]), a Frisian. The sixth book, as we have seen, describes the actual construction of a Rojas universal astrolabe. In the preface to this book Rojas says that, having a description written by Helt of the method of constructing the astrolabe, he resolved to include it, altering nothing. Rojas also remarks that he is indebted to Helt for much other help in matters relating to his work. He praises Helt for his valour combined with his erudition in all branches of learning ([90]). It will be seen that this praise was not unjustified.

It is possible to piece together a partial account of Helt's varied career from a number of obscure sources ([91]). Helt belonged to a rich, but not a noble, family in Groningen which became known in the sixteenth century when one of its members, Lambertus Helt (d. 1528) became Abbot of the Abbey of Aduard. The Groningen archives in 1549 and 1550 mention a merchant, Nicolaas Helt. A few years later we have record of a pastor, Hendrik Helt ([92]). Of Hugo Helt's parents and his early life we know nothing. He was born about 1525 ([93]), and came

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([89]) Rojas, see below, n. 90, uses the form 'Huo Held'; other variations encountered are Uuo, Uho, Vivo, Vivio, or Hugo Heltilius, or Heltelius.

([90]) Rojas, *op. cit.*, p. 225: «Cæterum cum hanc ipsam quam dico structuram, ab Huone Held nostro (qui ut in hac parte, ita etiam in cæteris, quæ ad nostra studia pertinuerunt, plurimum fuit mihi semper adiumento, cuius me hercule uirtus cum eruditione in omni disciplinarum genere par est) ea ratione ut neque addi illi, aut demi quicquam censuissem, scriptam inuenirem, eam ipsam ne uerbo quidem immutatio in nostrum librum transtulimus»; Rojas concludes his preface with the words: «Sed Huonem loquentem iam nunc audiamus», *op. cit.*, p. 226; cf. Pereira da Silva, *op. cit.*, p. 339.

([91]) Several of these were used by W. S. Boeles, 'Uvo Helt en Severinus Feyta; een Groningen en een Fries, bij de berenning van Leuven door Maarten van Rossem in 1542', *Bijdragen tot de geschiedenis en oudheidkunde, inzonderheid van de provincie Groningen*, vol. v (Groningen, 1868), pp. 37-50; a most useful article.

([92]) Boeles, *op. cit.*, p. 39.

([93]) This may be deduced from a letter written by Joachim Hopper in 1567, published in Joach. Hopper, *Epistolæ ad Viglium ab Aytta Zuichemum* (ed. by de Nelis), Utrecht, 1802, pp. 132-133.

to Louvain, where he lived in the St. Quintinusstraat in a house once called *Carsau* (94).

It was while he was still quite young, probably a student at the University of Louvain, that Helt achieved a certain fame. From 1521 until the the Peace of Cateau-Cambrésis in 1559, large areas of Europe were intermittently disturbed by wars between the Hapsburgs and the Valois. The fifth war between Francis I of France and Charles V was proclaimed by Francis in 1542 and concluded by the Peace of Crépy in 1544. At the outset of his war, Francis dispatched five armies to attack Charles' dominions in Artois, Luxembourg, Piedmont, Roussillon and Brabant. The last was invaded by troops from Gelderland and France, under the leadership of Martin van Rossem (1478-1555) and his lieutenant, le Sire de Longueval (95). Van Rossem's army laid seige to the city of Louvain on 2 August 1542. Devoid of adequate troops for defence, the city councillors, military chiefs and the rector of the University decided to try to negotiate with van Rossem. The latter demanded the complete surrender of the city and a high ransom, in return for guaranteeing the protection of the inhabitants and of their goods and property, and for allowing to leave freely those not wishing to swear allegiance to the French king. The Portuguese humanist and historian, Damião de Góis (1508-1596) (96), who had married

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This publication I have not seen, but the letter is quoted by Boeles, *op. cit.*, p. 42. Cf. below p. 54.

(94) Viglius ab Aytta, *Epistoloæ ad Joach. Hopperum* (ed. by Gabbema), Louvain, 1661, p. 105 (not available to me, but cited by Boeles, *op. cit.*, p. 43).

(95) For the general background, see H. Pirenne, *Histoire de Belgique* (7 vols.), vol. III, 'De la mort de Charles le Téméraire à l'arrivée du Duc d'Albe dans les Pays-Bas (1567)' 4th ed., Brussels, 1953, *passim*; on van Rossem, *Biographie nationale publiée par l'Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique*, vol. 20, Bruxelles, 1908-1910, *cols.* 145-159.

(96) His name, outside Portugal, is often written 'Damiano a Goes'. A useful summary of his life and work is Aubrey F. G. Bell, *Um humanista português, Damião de Góis* (Tradução... por António Álvaro Dória, seguida das Cartas portuguesas de Damião de Góis),

and settled in Louvain, had set out for The Hague. Hearing of the danger, he had returned to Louvain on the eve of the seige, had been invited to join the council of the city, and charged with inspecting the ramparts, which he found to be in a poor state of repair. The senate of the University then asked Damião de Góis to take command of the students, whom he divided into groups according to their 'nations', doing his best to inspire them with energy and confidence. There were suspicions about the trustworthiness of van Rossem, and two persons in particular, one of them Hugo Helt, the other a certain Severinus a Feyta, urged their fellow-students and the townsfolk to resist, and encouraged them by their example ([97]). The enemy were fired

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Lisbon, 1942; see also *Biographie nationale... de Belgique*, vol. VIII, Brussels, 1884-1885, cols. 24-27.

([97]) The prime source is Suffridus Petrus, *De scriptoribus Frisiæ, decades xvj. & semis: in quibus non modo peculiares Frisiæ, sed et totius Germaniæ communes antiquitates plurimæ indicantur, & veterum historicorum ac geographorum loci hactenus non intellecti explicantur: causæq; redduntur dilucidæ, cur veteres Germani præter meritum ruditatis & imperitiæ à quisbusdem in re literaria arguantur*, Cologne, 1593, pp. 100-104: Decas undecima, cap. 10 — 'VVo Helt'. Suffridus Petrus was himself a student at Louvain from 1547 until 1553, during which time he heard an account of the seige from Severinus a Feyta; Held was no longer there (*op. cit.*, pp. 103-104). Petrus also quotes at length a poem, about the seige and Helt's exhortation to resistance, written by another student, Cyprianus Vomelius a Stapert (*op. cit.*, pp. 101-103).

Petrus' account is presumably the source for the brief mention of this episode in the entry on 'Hugo Heltelius' in Valerius Andreas, *Bibliotheca Belgica: in qua Belgicæ seu Germaniæ inferioris provinciæ, urbesq. viri item Belgio vitâ scriptisque clar; librorum nomenclatura*, Louvain, 1623, p. 414, and the revised edition (with a different sub-title), Louvain, 1643, p. 399. Andreas' note on Helt is repeated (with very minor changes) in Johannes Franciscus Foppens, *Bibliotheca Belgica, sive virorum in Belgio vitâ scriptisque illustrium catalogus, librorumque nomenclatura continens scriptores à clariss. viris Valerio Andrea, Auberto Miræo, Francisco Sweertio, aliisque, recensitos, usque ad annum M. D. C. LXXX*, Brussels, 2 vols., 1739, vol. I, p. 495. Andreas and Foppens were used for the entry, 'Heltelius, Hugo' in A. J. van der Aa, *Biographisch Woordenboek der Nederlanden, bevattende Levensbeschrijvingen van zoodanige Per-*

on with an assortment of missiles from the ramparts, and retreated from the walls of the city. The garrison was prevented from fleeing (as their officers had done) by the students and inhabitants; «... honestæ matronæ puellæque, ubi virorum deerant operæ, in saxis ac telis portandis aliisque belli muniis calonum quasi vices supplebant...» ([98]). The show of resistance offered met only a feeble response from van Rossem's army which had no heavy artillery. The next day van Rossem struck camp and left, taking with him not only the mayor of Louvain, but also Damião de Góis. These two had been continuing negotiations with an increasingly impatient van Rossem when the firing had begun, and had been trapped in van Rossem's camp. Damião de Góis was not to regain his liberty for several months or until he had paid a heavy ransom, which later he tried in vain to reclaim from the city of Louvain. Certainly, its deliverance from the invader owed little to either its military or civic officials. A contemporary lawyer, Gérard le Prince, wrote of the siege that van Rossem, «... cuydant surprendre ladite ville, mais en ont esté reboutté, dont les clerq et femmes de Louvain en auront toujours honneur...» ([99]).

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sonen, die zich op eenigerlei wijze in ons Vaderland hebben vermaardgemaakt, vol. VIII, Haarlem, 1867, pp. 505-506. Later biographical dictionaries have ignored Helt. See also n. 98, below.

([98]) Johannes Isacus Pontanus, *Historiæ Gelricæ libri XIV*, Harderwijck, 1639, p. 826. Pontanus gives the names of others involved, referring to them all, including Helt as students; *cf.* Booles, *op. cit.*, pp. 41-43.

Gemma Frisius was in Louvain at this time and found himself, involuntarily, under arms, a fact which the mentioned in a letter written the following year to Johannes Dantiscus; Van Ortroy, *op. cit.*, p. 15.

([99]) Alexandre Pinchart, 'Récit de la guerre de 1542, par Gérard le Prince, contemporain', *Messager des sciences, historiques, des arts et de la bibliographie de Belgique*, Gand, année 1851, p. 228.

Damião de Góis wrote, for Charles V, a detailed account of the seige, published at Louvain in 1546; this edition I have not seen, but *cf.* Bell, *op. cit.*, pp. 26-27, 107. It was reprinted, in Simonus Schardius, *Historicum opus, in quatuor tomus diuisum: quorum tomus I, Germaniæ antiquæ illustrationem continet... tomus II, com-*

By 1545, Helt was no longer in Louvain ([100]). He had gone to Spain, where in 1549, at Salamanca, a small book with the following title was published:

Declaracion y uso del relox español entretexido en las armas de la muy antigua, y esclarescida casa de Roias, con el mesmo relox agora nueuamente compuesto por Hugo Helt frisio. Y romançado por Francisco Sanchez natural de las Broças, con algunas addiciones del mesmo. Año de .M.D.XLIX.

The colophon (f. 36[r]) reads:

'Fue impressa la presente obra en Salamanca por Juan de Junta. Acabose .27. de Septiembre. Año. de .1549 ' ([101]).

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præhendit ea, quæ sub Imperio Caroli V. Cæsaris, in diuersis locis ac regionibus acciderunt... [etc.], Basle [1574], vol. II, pp. 1869-1883: 'Damiani Gois equitis lusitani De captiuatate sua, et iis, quæ ad Lovanium à Longouallio Gallorum Duce acta sunt, ad Carolum Quintum Augustum uera narratio'; also in *Schardius redivivus...*, 4 vols. in 1, Giessen, 1673, pp. 620-631. Damião de Góis mentions Severinus a Feyta and two others, but not Helt, unless 'Bart. Heetueldius' be a bad recollection of the latter's name.

On the siege of Louvain, see also Petrus Nannius, *Oratio de obsidione Louaniensi. Aiunctus est dialogus de milite peregrino, eodem autore*, Louvain, 1543 (no mention of Helt); Herman vander Linden, *Geschiedenis van de stad Leuven*, Louvain, 1899, esp. pp. 152-155; *Biographie nationale... de Belgique, loc. cit.*; Boeles, *op. cit.*, pp. 37-38.

Andreas, *ibid.*, and Pontanus, *op. cit.*, p. 826, followed by Van der Aa, *op. cit.* p. 506 state that after the seige Helt, *i a.*, was ennobled by Charles V as a reward. Petrus, *op. cit.*, p. 101, only mentions the ennoblement of Severinus a Feyta. *Cf.* Boeles, *op. cit.*, pp. 40-42.

([100]) This fact may also be deduced from the letter written by Hopper in 1567; see above n. 93.

([101]) This book is very rare. There is a copy in the Museum of the History of Science, Oxford, and there are three copies in the Biblioteca nacional, Madrid. Bartolomé José Gallardo, *Ensayo de una biblioteca española de libros raros y curiosos*, 4 vols., Madrid, 1863-1889, vol. III, p. 459, no. 3830, in the entry for Francisco Sánchez de las Brozas, lists a copy in the Biblioteca de Medinaceli, the library

Helt dedicated his book to Juan de Rojas' father: 'Al Illustrissimo Señor el Marques de Poza mi Señor'. The dedicatory preface is dated at Salamanca, the 27 September 1549. Helt says that the Marqués is more accustomed 'en hazer mercedes' than 'en rescebir seruicios de sus criados', and that he has been treated 'humanissimamente' during three years' work in the house of the Marqués, without being able to give any recompense ([102]). This implies that Helt had joined the Marqués' house-hold in 1545 or 1546 and tallies well with the date he is said to have left Louvain. These dates are also those when Juan de Rojas appears to have written his commentaries on the universal astrolabe at his father's home in Monzón ([103]). It, therefore, seems very likely that Rojas had met Helt in Louvain and that he had brought him to Spain on his return.

None of the older authors who have given biographical notes on Helt seem to have known his book, published in 1549 ([104]). It is a curious work, describing (as the title

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of the Marqués de la Romana; *cf.* Palau y Dulcet, *op. cit.*, 2nd edition, vol. 6, Barcelona and Oxford, 1953, p. 536, no. 112896.

The collation of the copy at Oxford appears to be 4°; π^2 A⁴, B-D⁸, E⁴, with A1-3 misprinted A2-4. The foliation of the first gathering is also apparently incorrect. The dedicatory preface ends on f. 5ᵛ (=end of first gathering) and the first chapter begins on f9ʳ (=beginning of second gathering); no text seems to be lacking (see fig. 8).

Except for the title-page and two poems at the beginning, the book is printed thoughout in gothic type. The title-page is reproduced by Francisco Vindel, *Manual gráfico-descriptivo del bibliófilo hispano-americano (1475-1850)*, 12 vols., Madrid, 1930-1934, vol. IX, p. 45, no. 2754, *s. v.* Sánchez; see also vol. XII, p. 37.

The text of Helt's little book was reprinted in Francisco Sánchez de las Brozas, *Opera omnia, una cum ejusdem scriptoris vita auctore Gregorio Maiansio generoso valentino*, 4 vols., Geneva, 1766, vol. III, pp. 417-484.

([102]) Helt, *op. cit.*, f. 2ʳ.

([103]) See above, p. 32.

([104]) There is no mention of it by Petrus, Andreas, Pontanus, Foppens, Van der Aa, or Boeles in their works already cited, nor in Franciscus Sweertius, *Athenæ Belgiæ sive nomenclator infer. Ger-*

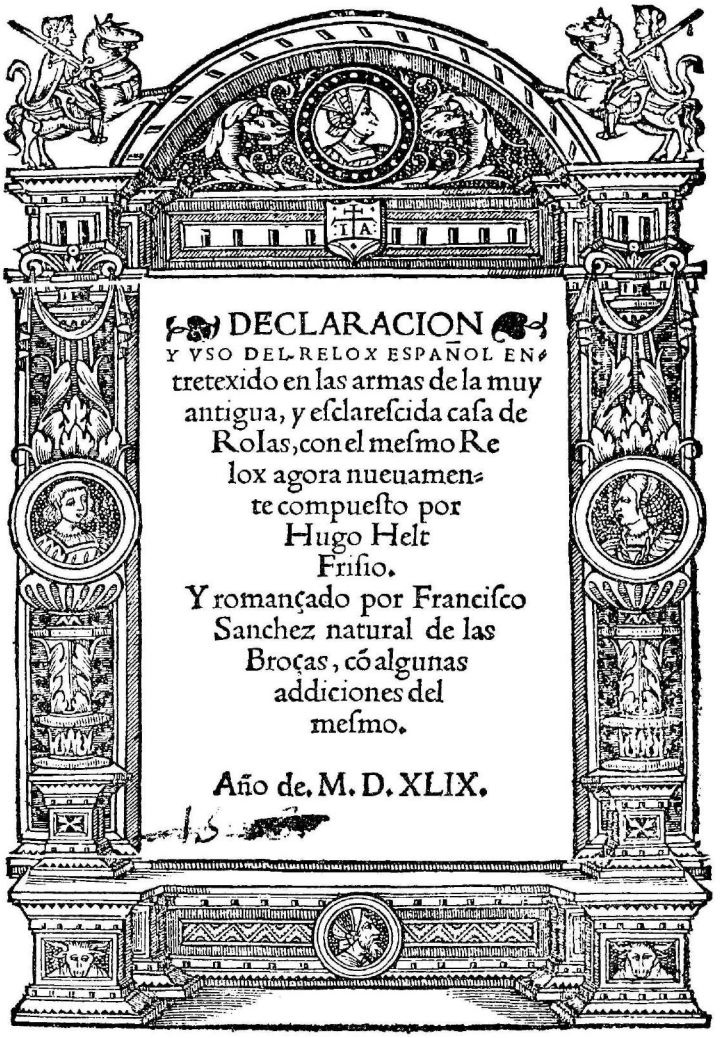

Fig. 7: The title-page of Hugo Helt's *Declaracion y uso del relox español entretexido en las armas de la casa de Roias... romançado por Francisco Sanchez... de las Broças...*, Salamanca, 1549, 4°. (Museum of the History of Science, Oxford).

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maniæ scriptorum, qui disciplinas philologicas, philosophicas, theologicas, iuridicas, medicas et musicas illustrarunt, Antwerp, 1628, p. 353, who has an entry on 'Hugo, vel Huo Heltilius'. It was, however, recorded by Marqués de Torre-Nueva, *Epitome de la biblioteca*

says) a sundial interwoven *(entretexido)* in the arms of the Rojas family. Furthermore, the sundial was placed in the arms by Helt. The explanation of this somewhat improbable idea is given in Helt's preface. Wishing to repay in some way the kindness shown to him by his master, the Marqués de Poza, he had for long been at a loss to know how to do so. However, seeing «poco dias ha» the coat of arms of the Rojas family, «parescia me ver en alguna manera estar en ellas la costumbre de los antiguos», who communicated to the people their marvellous doctrines, wise precepts and so forth, not only openly but also in a concealed or secret fashion so that what was divinely given to men should not become known to the unworthy. Helt considered, then, in turn a possible moralistic symbolic significance of each of the various charges in the Rojas arms, — the five stars which form the principal charge, the white cross «que la muy antigua genealogia de Portugal de los Pereyras, con muy propinquo parentesco traxo a su linage», the castles and lions (for Castille and León) indicating consanguinity with the kings of Spain, and the branches of fig-tree «que como cogidas primeramente en Alemaña, y trasplantadas despues en España, de ay adelante tan copiosamente han crescido, que aun oy en dia por toda España para señalar vna muchedumbre, de parientes anda por refran comun: mas son que los de Rojas» ([105]).

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oriental, y occidental, nautica, y geografica, de Don Antonio de Leon Pinelo... añadido, y enmendado nuevamente..., 2 vols., Madrid, 1737 and 1738, vol. II, f. mccviii[r], and by Navarrete, *op. cit.*, p. 218 (quoted by Pereira da Silva, *op. cit.*, pp. 338-9). In addition to the more recent references given in n. 101, above, there is an account of this work in Picatoste y Rodríguez, *op. cit.*, p. 287, no. 737, *s. v.* Sánchez, Francisco.

([105]) The basic coat-of-arms of Rojas is *en campo de oro cinco estrellas azules* [arranged 2, 1 and 2] (López de Haro, *op. cit.*, 2.ª parte, p. 366, where it is illustrated) but it varies for different branches of the family. Francisco Piferrer, *Nobilario de los reinos y señoríos de España*, 2nd ed., 6 vols., Madrid, 1857 ff., vol. I, p. 106, nos. 261 and 262, quotes Luis Zapata's poem 'Carlos famoso',

> *'Cinco estrelas azules esculpidas*
> *En ese escudo de oro reluciente*

Helt thought of writing a commentary on the arms expounding the moral lessons of their symbolic content and their exemplification of the virtues of the house of Rojas. Deciding against this, he found another solution to his problem: «y luego se me offrescio modo, y manera como se ponga algo en torno de aquellas armas, en lo qual tambien quasi como en enigma entiendan otros, que deuen tomar para su imitacion, lo que V. S. perseuerando con gran constancia en esta vida haze». This embellishment was a sundial drawn around the arms. A first circle, called the 'Calendario general' surrounded the arms 'en manera de feston, o guirnalda'. To this were added 'otras ciertas cosas' which enabled one to tell the time by day or night throughout Spain, Corsica, Sardinia, Sicily, nearly all the islands of the Mediterranean, a large part of Italy and France many other regions (not quite universal!). Helt remarks that among these additions were many that were as useful in everyday life as 'tables' (*sc.* astronomical tables) were at all times ([106]).

The absence of any illustration of Helt's sundial is a great handicap to obtaining a clear idea of its appearance, or of the disposition of the scales and lines drawn upon it. That a full-size illustration, usable as an instrument, accom-

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Son de los Rojas *armas conocidas,*
Un linage famoso y escelente.
Junto á Briviesca fueron las manidas,
En Bureva, én Castilla, de esta gente;
Aunque por todo el mundo, do la llama
del sol toca, estendida está su fama'

and illustrates two variations of the coat on pl. 111, nos. 261 and 262. *Cf.* also Vilar y Pascual, *op. cit.*, vol. VIII, p. 129; J. B. Rietstap, *Armorial général...*, Gouda, 1884-1887, vol. II, p. 595, and H. V. Rolland, *Planches de l'Armorial général de J.-B. Rietstap*, The Hague, 1921, pl. CLXXXI. Some of the other charges mentioned by Helt are to be seen in the armorial book-plate of Manuel Rojas y Almansa, an author of various legal works of the mid-eighteenth century, reproduced by Francisco Vindel, *Ensayo de un catálogo de ex-libris ibero-americanos (siglos XVI-XIX)*, 2 vols., Madrid, 1952, vol. 2, p. 110, no. 742.

([106]) Helt, *op. cit.*, ff. 2^{r}-3^{v}.

panied the book is certain. Unfortunately, none of the four known copies contains any illustration other than the decorative border of the title-page and a simple diagram of the stars forming the constellation of the Great Bear ([107]).

lir de ſus quicios/ recibira la ſentencia daquel juez ſupremo: por la qual les ſera mandado/ que entren en el reyno de ſu padre aparejado para ellos deſde la cõſtitucion del mundo. ¶Porque tuue hambre Chriſto el juez y dieron le de comer. Tuue ſed/ y dieron le a beuer. Anduue deſnudo/ y dieron le veſtidos ꝛc. Toda via aun q̃ no puede al hombre venir mejor coſa que eſta: pues es lo ſummo de nueſtro naſcer/ y morir: y a quiẽ/ como a algun hito/ todas nueſtras obras/ y penſamientos ſe han de endereçar: porq̃ ay a cada paſſo muchos/ cuya ſalud depende/ y ſe ſuſtẽta de la liberalidad/ y limoſnas de. V.S. quedare rogando a Dios ſiempre con muy ardientes deſſeos/ y oraciones que la Illuſtriſſima perſona/ y eſtado de. V.S. por muchos años ſea guardada/ y acreſcẽtada: y deſpues quando aya ajuntado mas buenas obras ſobre las paſſadas: nueſtro Señor Jeſu Chriſto tenga por bien, la dilacion del celeſtial premio recompenſar ſe la ricamente con la grãdeza de ſu gloria. En Salamanca. a. 27. de Septiẽbre de. 1549. años.

De V.S. Illuſtriſſima criado/ y ſeruidor/ que ſus Illuſtriſſimas manos beſa.

Hugo Helt friſio.

9

¶ Capitulo primero del vario vſo del Relox Eſpañol, que puſimos en las armas de la muy illuſtre caſa de Rojas.

Bien diligẽtemente conſiderare las coſtumbres de nueſtros tiẽpos entre ſi, tambien creo, comigo dubdara, ſi por ventura mas nos deuemos enojar de la deſuerguença de algunos, que todo ſu trabajo ponen en falſar las coſas, que ſon neceſſarias para la vida: o ſi nos auemos de doler del poco ſaber de muchos: o quexar antes de la paciencia, y manſedumbre de todos. Porque cierto es coſa mucho para doler, que por el engaño de la abominable auaricia anden oy las mercaderias malas tan afeytadas, y tan ſemejantes a las buenas: que nunca nos lleguemos a cõprar a la tienda ſin ſoſpecha, y miedo de ſer engañados. En el tiẽpo paſſado los Atenienſes ſolian maldezir en los altares publicos al que no moſtraua el camino a quiẽ fueſſe perdido. Segun eſto, que ſe podria mandar y eſtableſcer, contra los q̃ en alguna manera tienen por coſtumbre de embayr, y engañar nueſtro juyzio: poniendo nos delante ciertas ſeñales mentirosas, con las quales occultamente nos apartan del derecho camino? Tambien ciertamente nos deuria fatigar, hallar ſe comunmente hombres, que no ſolamẽte ſe dexen enlazar deſte engaño tan deteſtable: mas aun deſpues de engañados ſean eſcarneſcidos de

B hombres

Fig. 8: Ff. 5[v] and 9[r] of Helt, *op. cit.*; the conclusion of Helt's dedication, and the beginning of chapter 1. (Museum of the History of Science, Oxford; see n. 101).

From the text of the book, we learn that the instrument was circular, with a small concentric volvelle (rotatable disc). It was printed on paper from an engraved plate

([107]) f. 27[r]. The four copies are those mentioned in note 101, above. If the copy recorded by Gallardo (n. 101, above) is not one of these, then it is possible that it contains an illustration of the instrument. Gallardo mentions that it has a 'frontispiece', but he

and, for stiffness, the volvelle was reinforced with additional paper on the back. The instrument was to be stuck on a thin smooth piece of wood. It had an alidade, «vna regla, o muestra: que llaman los Mathematicos Dioptra», which was also illustrated full size. This alidade was to be stuck on a wooden rule, care being taken not to strech the paper so as to render inaccurate the divisions of a scale on one of its arms. A pair of sights (each with a small hole for indirect solar observations, and a larger hole for direct observations) was to be attached to the alidade, which was pivoted at the centre of the instrument by a nail 'bien redondo', after a rebate had been cut on the underside so that it cleared the thickness of the volvelle ([108]).

It is evident that only one side of the instrument was used. It is also clear that it was of a fairly large diameter, certainly larger than could have been printed on a sheet the same size as the quarto pages of Helt's book. If it was included in the book, it must have been on a much larger folded sheet. In an additional, unnumbered chapter at the end of the book, Helt counters, and compromises with, certain objections levelled against his instrument by friends to whom he had shown the book and the engraving. The complaints concerned, on the one hand, the necessity of sticking the parts on to wood and making the alidade, and, on the other, the need to carry so large an instrument out of doors in order to make observations: «... que muchos, o los mas tendrian por odioso salir cada vez cargados... con tan grande tabla...» ([109]). Helt suggests, therefore, that the sheet on which the instrument is printed, be pinned on a wall indoors and that, instead of an alidade, a thread

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may have been referring to the wood-engraving framing the title. In the eighteenth century, the publishers of the complete works of Sánchez appended this footnote to a poem by Juan Mallara which appears at the beginning of Helt's book: «Qualquiera diligencia que ayan hecho los Impresores desta Obra, no han podido encontrar la estampa deste Relox; por esso supliquen à los que lo tuvieran sean servidos comunicarsele, para que lo manden escupir, para mayor inteligencia de la Obra», Sánchez, *op. cit.*, p. 420.

([108]) Helt, *op. cit.*, ff. 11^{r}-14^{v}, especially f. 13^{r}.

([109]) f. 33^{v}.

with a sliding bead ([110]) be attached to the centre. For the necessary out-door observations, he recommends a simple altitude quadrant, for which he apparently also provided a full-size illustration which could be struck on wood and then provided with a pair of fixed sights and a plumb–line, with a little lead weight ([111]).

Helt, nevertheless, justifies the size of his instrument in words to which many instrument makers would have subscribed:

> «y quanto lo que toca a la grandeza del instrumento, dire que en pequeño instrumento no se podian muchas cosas poner distinctamente: porque todos saben, que quanto mayor es el instrumento Mathematico, mas claro tiene los vsos, y mas distinctos: y que bien auia yo visto, que era grande, pero parescia me tolerable con yr compensado de muchas vtilidades» ([112]).

Helt's instrument was rather more than sundial, almost a simplified astrolabe, as a summary of the book will show:

f. 9[r] ([113]) chap. 1: Lists the uses of the 'Relox Español que pusimos en las armas'. Helt complains bitterly against foreign sundials, imported into and sold in Spain, which are unsuitable for use there because they were made for use in other latitudes: «Por que como yo viesse por toda España traer se vnos reloges de Sol, y dedicar se en cada parte, como si para alli fueran hechos (no siendo ellos sino para vna eleucion de polo fabricados) parescio me que deuia publicar aquella manera de Relox, que en las armas de la... familia de los de Rojas auia yo entretexido». This instrument of his, however, is accurate since it is suitable for 'todas las naciones del Señorio de España'. With it one can tell

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([110]) «... por el qual hilo se en hilara vn grano de aljofar, o vna cuentezilla pequeña, o vna cabeçuela de alfiler...»; f. 34[r].

([111]) *Ibid.*

([112]) f. 33[v].

([113]) For simplicity, I have only noted the folios on which the chapters begin.

the time by day or night, and use it to regulate 'los otros Reloges de campanas' ([114]). It contains clearly and succinctly what is to be found in 'los comunes calendarios', namely dominical letters, golden numbers, moveable and fixed feasts, etc. All this would seem enough for «hombres vulgares cuyo sentido no se leuanta a cosas mas subtiles» (!), but it has, in addition, characteristics «que en los Astrolabios y otros instrumentos Mathematicos los hombres curiosos suelen buscar», namely, the possibility of ascertaining Italian hours, unequal (planetary) hours, times of sunrise and sunset, the altitudes of stars, the azimuth of the sun and its place in the ecliptic, the difference between right ascension and celestial longitude, the right ascension of the sun, the height of buildings, the width of a ditch or river, and the depth of a well. Some of these are useful, he says, for drawing meridians and determining latitudes.

f. 11^{r} — chap. 2: Describes the scales and lines on the instrument, and its assembly. As might be expected from the uses ennumerated above, it has a shadow-scale, and hour-lines for various horary systems, enclosed within a circular zodiac/calendar scale, an equinoctial circle and scales of degrees for measuring altitudes. In the centre, the volvelle carries dominical letters and golden numbers for finding the date of Easter.

The remaining chapters explain how to use the instrument to find:

f. 14^{r} — chap. 3: The dominical letter for a given year.
f. 14^{v} — chap. 4: Fixed feasts.
f. 14^{v} — chap. 5: The golden number for a given year.
f. 15^{r} — chap. 6: Easter and movable feasts.
f. 16^{v} — chap. 7: The place of the sun in the ecliptic.
f. 16^{v} — chap. 8: The declination of the sun. This is done by using the scale on the alidade to measure the angular distance between the ecliptic and equinoctial circles. Presumably, these circles are disposed as in the stereographic projection on an ordinary astrolabe.

([114]) *i. e.* striking clocks.

f. 17r — chap. 9: Right ascension.
f. 17v — chap. 10: Altitudes of the sun and stars, using the alidade as on an astrolabe.
f. 18r — chap. 11: Equal hours by day ('horas communes del dia'). The instrument is used as a self-orientating altitude sundial. The adjustment for latitude of the alidade is effected by adjusting it in accordance with a series of numbered divisions on the instrument, each with its own hour-lines. These divisions are numbered according to the 'climates' of Ptolemy. Helt includes an alphabetical list of several hundred places in Spain, giving their climates.
f. 23v — chap. 12: This chapter describes how to draw a meridian on a flat surface, using a gnomon, and compasses.
f. 24v — chap. 13: The 'climate' ('la orden, o classe horaria') and the latitude of a place.
f. 25r — chap. 14: The time of sunrise and sunset, and the lenght of day and night.
f. 25v — chap. 15: Unequal hours.
f. 26r — chap. 16: The time at night, by a star of the Great Bear, using the alidade and the same method of latitude adjustment as in chap. 11, above. (This is not the method of a nocturnal, which uses a central hole to observe the pole star, while the rule is aligned on a star in the Great Bear).
f. 29r — chap. 17: Italian hours.
f. 29v — chap. 18: The height of a building, etc., by its shadow.
f. 31r — chap. 19: Altitudes, without use of shadow.
f. 31v — chap. 20: Horizontal distances (*e. g.* the width of a field), using the instrument as a cicumferentor.
f. 32v — chap. 21: Depths (*e. g.* of a well).
f. 33r — additional chapter, mentioned above (pp. 44-45).

Many of these problems are similar to those discussed by Juan de Rojas in his commentaries on the universal astrolabe ([115]), and the influence on Helt's instrument of

([115]) See above, pp. 12-15.

the design of all types of astrolabe, especially of the scales on the back, is evident. Nevertheless, Helt's instrument appears to be *sui generis*. However, there is in the Museum of the History of Science, Oxford, a somewhat later astronomical instrument, supposedly of Spanish origin, which of Helt's. On one side there is a lunar volvelle within a

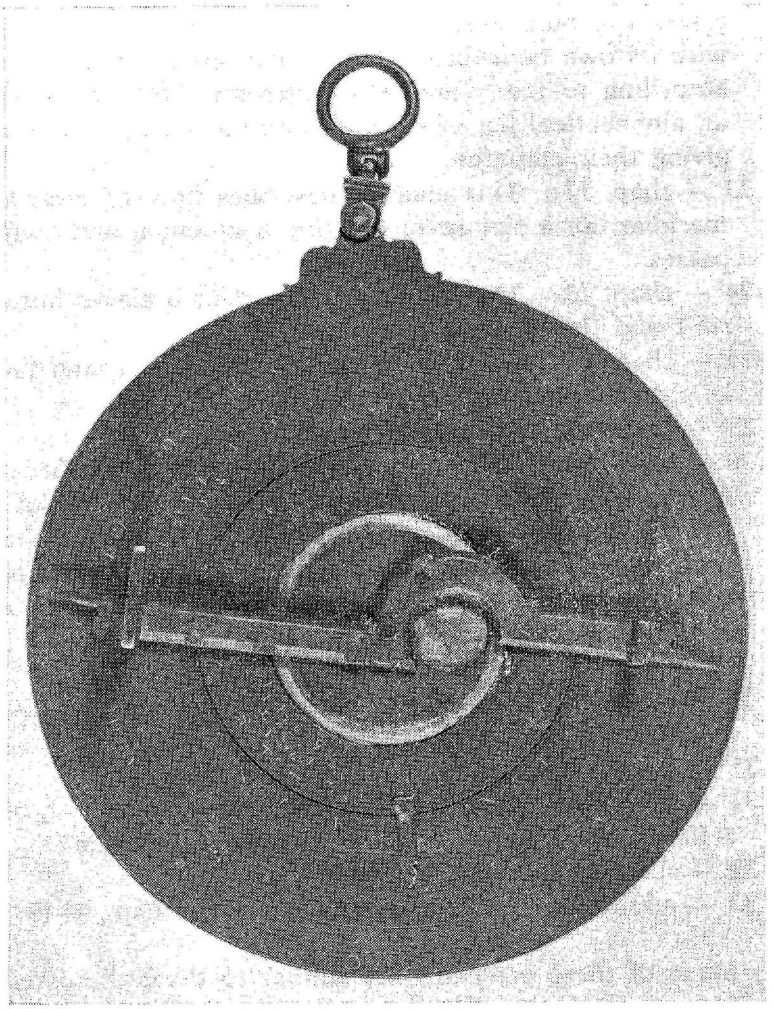

Fig. 9: Front of an anonymous ?Spanish astronomical instrument, ?17th century; brass, diam. 214 mm. (Museum of the History of Science, Oxford, no. 57-84/269).

might almost be considered a smaller, two-sided, version zodiac/calendar scale and a scale of equal hours, with the names of thirteen fixed stars; on the other side there are two quadrants of 90° each, a shadow square, and an unequal hour diagram. The instrument is used with an alidade ([116]).

That Helt was primarily addressing a lay audience is clear from much of the phraseology and from certain footnotes defining elementary mathematical and astronomical terms ([117]). He makes an interesting remark when describing the scales of degrees, of which there are two:

> «... tienen la misma diuision, y descripcion, saluo que en la vna esculpimos numeros de las Indias (*que* se llaman Cifras) [= our Arabic numerals] y en la otra cuenta Castellana: para los que no supieren contar mas de por la vna» ([118]).

The concluding sentences of chapter 1 are also worth quoting. After the enumeration of the uses of his instrument, Helt continues:

> «... y otras cosas semejantes: las quales el vulgo muchas vezes las tiene en poco, por la flaqueza de su ingenio. Mas por*que* se hallan toda via muchos dotados

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([116]) This instrument is neither signed nor dated. It is probably of the seventeenth century, and certainly later than 1582, as the zodiac/calendar scale is Gregorian (♈ 0° = 19 ½ March); diam. 214 mm.; ref. no. 57-84/269. See F. R. Maddison, *A Supplement to a Catalogue of Scientific Instruments in the Collection of J. A. Billmeir, Esq., C. B. E.*, Oxford and London, 1957, p. 91, no. 269. A more elaborate and much earlier instrument of the same general type is that described and illustrated by R. T. Gunther, *Early Science in Oxford*, vol. III 'Astronomy', Oxford, 1923, pp. 135-140, no. 56; this instrument is to be dated *c.* 1430 and is now in the Museum of the History of Science, Oxford.

([117]) *E. g.* 'diameter', 'centre', and 'ecliptic' are explained ff. 13^{v}, 16^{v}.

([118]) f. 11^{r}. For systems of counting akin to what Helt is here referring to, see Karl Menninger, *Zahlwort und Ziffer. Eine Kulturgeschichte der Zahl*, 2 vols, in 1, Göttingen, 1958, vol. 2, pp. 3 ff.

de mejor naturaleza y polido, que huelgan de emplear algun tiempo en conoscer estos secretos: por hazer plazer a estos tales determine de poner la manera como todo esto se puede tratar. Principalmente, porque no ay en Español (a lo menos que yo lo sepa) cosa escripta hasta agora: de donde facilmente estas cosas se pueden saber» ([119]).

Hugo Helt, the Frisian, it seems, must be regarded as a pioneer populariser of science in the Spanish vernacular. However, his book was originally written in Latin, though the passage above leaves no doubt that he wanted it to appear in Spanish. The translator, Francisco Sánchez de las Brozas (1523-1600) became professor of Greek in the University of Salamanca, and is remembered as a great scholar and humanist, a pioneer in the study of general grammar and the philosophy of language ([120]). Sánchez' translation of Helt's little book was his first published work ([121]). It is not possible to determine what were the 'algunas addiciones' which he made to Helt's text ([122]), but Sánchez was no hack translator and certainly was interested in scientific matters; twenty-five years later, in 1574, his *Sphœra mundi, ex varijs autoribus concinnata* ([123]), was published at Salamanca.

([119]) f. 10[v].

([120]) See the life of Sánchez by Gregorio Mayans y Siscar in Sánchez, *op. cit.*, vol. I, pp. 1-121; also Aubrey F. G. Bell, *Francisco Sanchez el brocense* (Hispanic Notes & Monographs... issued by the Hispanic Society of America, vol. VIII), Oxford, 1925, and the bibliography, *ibid.*, pp. X-XII; and Picatoste y Rodríguez, *op. cit.*, pp. 286-287.

([121]) Bell, *op. cit.*, p. 82; Picatoste y Rodríguez, *op. cit.*, p. 287, no. 737.

([122]) Picatoste *ibid.*, thinks that they «no alteran el texto, y se reducen á la explicación de los términos de Gnómonica necessarios para comprender el libro, y á útiles, pero breves observaciones, donde había necesidad de aclarar algún punto»; presumably, referring to the very few footnotes, but he also mentions the warning against buying imported sundials which, however, it is clear from the text, is Helt's not Sánchez'.

([123]) Palau y Dulcet, *op. cit.*, vol. VI, Barcelona and London, 1926, p. 431; Bell, *op. cit.*, pp. 76, 89-90; and Picatoste y Rodríguez, *op. cit.*, p. 287, no. 740 record only the 1579 edition. The latter praises this little book for its clarity and precision. Sánchez used cosmology

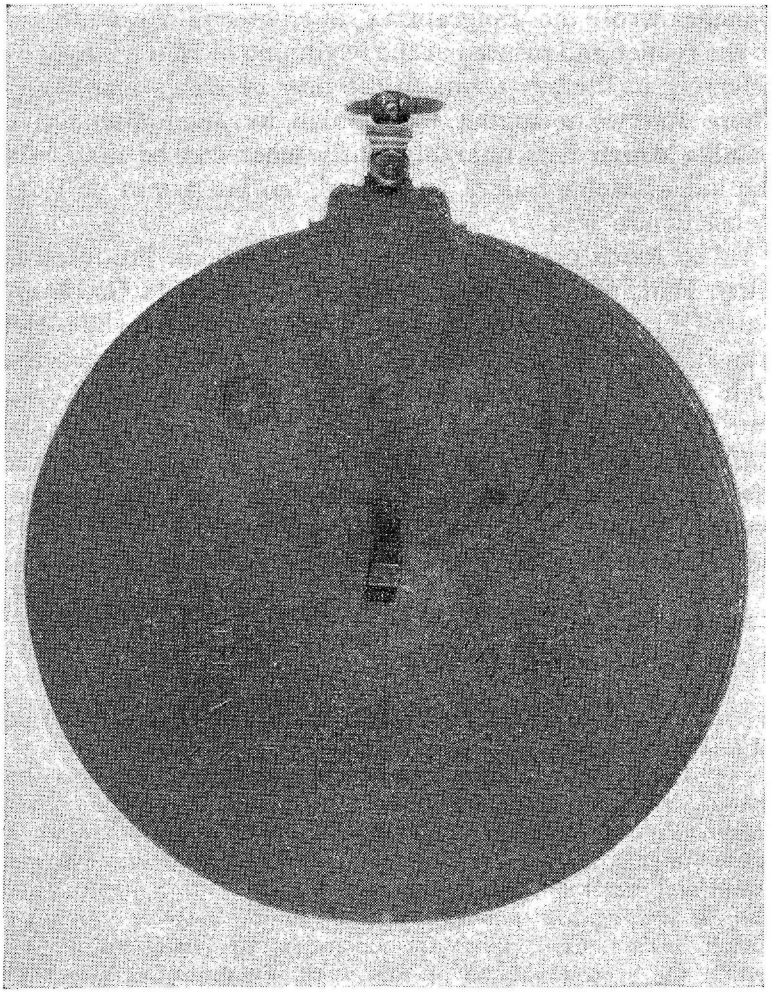

Fig. 10: Back of the astronomical instrument shown in fig. 9, (Museum of the History of Science, Oxford).

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to clarify certain passages in classical literature. He believed in the immobility of the Earth, though a contemporary fellow-countryman, the Augustinian monk Fray Diego de Zuñiga could accept the Copernican theory, for which he was praised by Galileo; Bell, *op. cit.*, pp. 75-76, 143. Sánchez also edited the *De situs orbis libri tres* of Pomponius Mela (1574 and 1579; Picatoste, *ibid.*, nos. 738 and 739; Bell, *op. cit.*, p. 89).

translator and certainly was interested in scientific matters; Sánchez wrote the 'Epigramma', of eighteen lines, addressed to the reader and printed at the beginning of Helt's book ([124]), referring in literary terms to the uses of Helt's instrument. There follows a sonnet in Spanish by Juan Mal-Lara of Sevilla, which lists unambiguously what can be done with the aid of Helt's 'nueva invencion', 'en las Armas de Rojas Relox dando' ([125]).

The *Relox español* was not the only book produced by Hugo Helt, who was said to be very learned in Greek and Latin ([126]). Some time before 1545, probably while Helt was still at Louvain, Conrad Gesner (1516-1565) heard that Helt was writing a *Dialectica,* but no-one except Gesner and the editors of later versions of his *Bibliotheca Universalis* refers to it ([127]). No such book by Helt has been traced. He did, however, translate from the Greek the sermon on the Nativity of Christ, delivered by Gregory of Nyssa on 25 December 386 ([128]), and one or both the sermons on

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([124]) Helt, *op. cit.*, f. 1^{v}.

([125]) *Ibid.*, f. 2^{r}.

([126]) Sweertius, *ibid.*, followed by Andreas, Foppens, Pontanus, all *ibid.*

([127]) «Vivio Helt nobilis Groningensis natione Phrysius, hoc tempore, ut audio, dialecticam scribit»; Conrad Gesner, *Bibliotheca Vniversalis, siue catalogus omnium scriptorum locupletissimus, in tribus linguis, Latina, Græca, & Hebraica: extantium & non extantium, veteram & recentiorum in hunc usq; diem doctorum & indoctorum publicatorum & in Bibliothecia latentium,* Zürich, 1545, f. 626^{v}. What Gesner means by 'dialectica' is defined in the second volume of this work, *Pandectarum siue partitionum uniuersalium...* libri XXI, Zürich, 1548, f. 44, but this term means anything from an original work on logic to a commentary on an ancient author who wrote on logic. In Josias Simler's Epitome, with additions, of Gesner's *Bibliotheca,* Zürich, 1574, p. 681, Gesner's 'scribit' has become 'scripsit'; similarly in Johannes Jacobus' revision of Simler, Zürich, 1583, p. 819. Petrus, *op. cit.*, p. 100, quoted Simler. Sweertius, Andeas, Foppens and Pontanus do not mention the *Dialectica.*

([128]) J.-P. Migne, *Patrologia graeca,* vol. 46, Paris, 1863, cols. 1127-1150; see Johannes Quasten, *Patrology,* 3 vols., Utrecht and Brussels, n. d., 1953 and 1960, vol. III, p. 227. Quasten regards this sermon as 'highly important for the history of the feast of the Nativity'.

St. Stephen which Gregory gave on the two following days ([129]). These were printed by Portonaris at Salamanca in 1553 ([130]). Helt is said also to have translated a *Catena,* or anthology of snippets, concerning Isaiah ([131]), from a manuscript in the Colegio de San Bartolomeo, Salamanca, and this too is supposed to have been published at Salamanca in 1553 ([132]). More relevant, however, to the present study is the *Planisphærium* in Spanish, which Helt is recorded as having published at an unspecified date, also at Salamanca, but of which I have failed to find a copy. One source could be interpreted as meaning that this *Planisphærium* was also a translation from the Greek ([133]). If so, then it must have been Ptolemy's treatise on the ordinary astrolabe ([134]). Alternatively, it might have been an original work, a translation of a contemporary book

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([129]) Migne, *op. cit.*, vol. 46, cols. 701-736; Quasten, *op. cit.*, vol. III, p. 278.

([130]) 'Verti è Graeco, *Gregorij Nysseni Homelias in Christi natalem, & B. Stephanum protomatyrem.* Salamticæ anno 1553.8. [=8vo]...', Sweertius, *ibid.;* also Andreas, and Foppens, *ibid.*, Pontanus, p. 827, Van der Aa, p. 506. This book is extremely rare and I have not seen a copy or a reproduction. There is a copy in the Bibliotheca nacional, Madrid; private communication, 22 October 1960, from Señorita Luisa Cuesta of that library.

([131]) *Cf.:* Quasten, *op. cit., passim.*

([132]) '(Vertit è Graeco...) *Catenam Græcorum Patrum in Esaiam Prophetam.* Ibidem [sc. Salmanticæ]', Sweertius, *ibid.*, adds the information about its source: '... è Codice Maniscripto Colegii S. Bartolemei Salmanticæ'; likewise Foppens. Pontanus, *ibid.*, says 'vidi & ipse exemplar ipsuismet manu exaratum, quo interpretatus Latine est catenam Græcorum patrum in Esaiam Prophetam'. The marginal note alongside this reads: '*Hugo* Hiltilius Frisius Salamanticæ professoris'! I have not been able to trace a copy of this translation.

([133]) Sweertius, *ibid.*, who has the phrase, '*Planisphærium,* Ibidem [*sc.* Salmanticæ]. 4. [=4 to] linguâ Hispanicâ.', as the last item in a tabulated list of three works (of which the other two are the patristic translations already mentioned), following the words 'Vertit è Græco'.

Andreas and Foppens, *ibid.*, have the sentence: 'Edidit etiam *Planisphærium.* Ibid. 4. Hispanicè'. Pontanus does not mention it.

([134]) See above, p. 3. The *editio princeps* appeared at Basle in 1536.

on the astrolabe, or even a Spanish version of Helt's contribution to Rojas' book on the astrolabe (in the title of which occurs the word, *planisphærium).* In any event, Helt's *Planisphærium* would be of considerable interest, both intrinsically and because it was published not in Latin, but in a vernacular ([135]).

The publication of at least two of his books in Salamanca lends some credibility to statements that Helt was resident there, and died there ([136]). There is, however, some evidence concerning the latter part of Helt's life, which if not incompatible with these statements, at least suggests they might not be reliable.

On 29 June, 1567, Joachim Hopper wrote from Madrid to Viglius van Aytta van Zuychem (1507-1577), the Dutch statesman and jurist saying that he knew well Hugo Helt, of Groningen, a learned man of a rich and ancient family, who had come there and who had spent twenty-two years in exile in Spain of his own free-will. Helt, learning that Viglius had built a house in Louvain, had decided to return to that city which he had left when he was about twenty years old. He would live under Viglius' protection, using his own money there, for he had an annual income (? in Louvain only) of more than eight hundred (? florins) ([137]). Viglius replied to Hopper on 24 July. He told Hopper that

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([135]) There remains the possibility that *Planisphærium* (a Latin version of the real title if the book was, indeed, in Spanish) is a reference to Helt's book on the *relox español,* published in 1549. However, the *Planisphærium* is recorded by the Marqués de Torre-Nueva, *op. cit.,* vol. II, cols. 994-995: 'Hugon Heltilio, Natural de Groninga, el *Planisferio,* 1553, 4. en Castellano.'; this in the same section (Titulo I) of the appendix (III) of additions in which is separately listed Helt's book on the *relox.* This entry raises the suspicion that it is merely a conflation and translation of information found in Sweertius, Andreas or Foppens.

([136]) 'Salmanticæ annis grauis corporis vinculo soluitiur', Sweertius, *ibid.*; '... vixit juvenis Lovanii: Salmanticæ in Hispania consenuit, & è vita decessit', Andreas, Foppens, *ibid.,* and slightly changed in Pontanus, *op, cit.,* p. 827.

([137]) Hopper, *ibid.,* paraphrased from the translation in Boeles, *op. cit.,* p. 42.

he had bought the very house where, he had heard, Helt had once lived ([138]). Hopper wrote again to Viglius on the 14 October of the same year, to say that he had tried to persuade Helt to go, but that the man had become so much a Spaniard that he preferred a miserable life in Spain to a happy one in his fatherland; Hopper compared him to Ulysses. Helt had spent twelve whole years on the construction of a self-filling oil-lamp which showed the time by the light of the flame ([139]). Hopper believed Helt lost both the oil and the invention! Helt said he would undertake the journey in the spring of the next year, but Hopper thought he would stay in Spain permanently ([140]). Nearly four years later, Helt was still in Spain. Hopper wrote on 18 Frebruary 1571 that Helt was working in a quarry or mine *(fodinae)* some thirty-two miles from Madrid. This mine belonged to the Fuggers, and Helt was friendly with the overseer. Hopper was quite unable to understand why a man should prefer life as a workman to the aristocratic life that would be his in Louvain, or why so learned a man should shun the company of men science and letters ([141]).

A deed of 1586 in the archives of Groningen concerning some land in Adorp mentions 'des hochgelertt doctor Vivo Helt'. From another document, dated 15 August 1595, in

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([138]) Viglius ab Aytta, *op. cit.*, p. 105, as summarised by Boeles, *op. cit.*, See also above, p. 34.

([139]) Hopper, *op. cit.*, p. 140, paraphrased from Boeles, *ibid.* On the subject of the lamp, Boeles' translation reads: '... eene lamp, die telkens zich zelve van olie voorzien en te gelijk door de uitwerking der vlam den tijs moest aanwijzen'. This is curiously reminiscent of the Dutch clock-lamps, usually dated to the eighteenth century. Such clock-lamps consist of a pewter stand and oil-lamp, with a glass vessel atached to the lamp at the end opposite the wick. A strip of pewter graduated with a scale of hours runs vertically down the side of the glass vessel, which is filled with oil. As the lamp burns, the level of the oil falls in the vessel indicating the time on the adjacent hour-scale, wich is illuminated by the burning wick. See Ernst von Bassermann-Jordan, *Uhren*, 4th rev. ed. by Hans von Bertele (Bibliothek für Kunst- und Antiquitätenfreund, vol. VII), Braunschweig, 1961, pp. 323, 324, 340.

([140]) Hopper, *ibid.*; Boeles, *op. cit.*, p. 44.

([141]) Hopper, *op. cit.*, p. 304; Boeles, *ibid.*

the same archives, it appears that Helt died in 1594 or 1595 ([142]). The little we know of his life at least suggests that Hugo Helt fully justified the respect accorded him by his contemporaries, Juan de Rojas who knew him, and by Suffridus Petrus, who heard about him in Louvain, the city he had helped defend, and who wrote:

> Cum eruditione, prudentia, comitate parem sibi nullum habere dicatur ([143]).

Acknowledgements

The preparation of this article has led me to seek help of the most diverse kind from many people. In particular, I should like to thank Señorita Luisa Cuesta of the Biblioteca nacional, Madrid; Monsieur Marcel Destombes of Paris; Dr. Mary Holbrook of the Historisches Museum, Frankfurt am Main; Mr. Joan L. Gili of the Dolphin Book Co., Oxford; my father, Dr. R. E. W. Maddison, Librarian of the Royal Astronomical Society, London; my brother, Mr. R. E. Maddison; Dr. H. P. F. Mercken of Linacre College, Oxford; Mr. J. W. F. Mulder, Librarian of the Oriental Institute, Oxford; Mr. D. G. Neill, Assistant Librarian, Department of Printed Books, Bodleian Library, Oxford; Dr. J. D. North, Nuffield Research Fellow in the History and Philosophy of Science, Oxford University; Mr. F. J. Norton, Under-Librarian of the University Library, Cambridge; Professor Jacques J. O. Palgen of the International Training Center for Aerial Survey, Delft; Miss Clara Luisa Penney, Librarian of the Hispanic Society of America, New York; Mr. D. A. Sykes of Mansfield College, Oxford; Mr. G. L'E. Turner and Mr. W. F. Ryan, Assistant Curators of the Museum of the History of Science, Oxford; Mr. and Mrs. R. S. Webster of Winnetka, Illinois; and Mr. J. Wrigth of Worcester College,

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([142]) Boeles, *op. cit.*, pp. 44-45. When Petrus wrote in 1593, he was unaware that Helt was still alive, for he says: 'Floruit autem maximè Vvo Helt circa annum 1560', *op. cit.*, p. 104.

([143]) Petrus, *op. cit.*, p. 100.

Oxford. I am also indebted to the late Professor L. A. Mayer of the Hebrew University, Jerusalem; and to the late Dr. E. Weil, of London. That the article was ever written is owing to the encouragement of Professor Luis Mendonça de Albuquerque of the University of Coimbra, with whom I first discussed it over five years ago. Throughout, my guide has been one of the very few who have troubled to examine closely the work of Juan de Rojas, the late Professor Luciano Pereira da Silva, who finished his lucid and perceptive study in Coimbra in May 1926.